Proceedings of the Thirteenth Annual Aquatic Toxicity Workshop:
November 12-14, 1986
Moncton, New Brunswick

Compte rendu des communications do treizième atelier annuel sur la toxicitè aquatique:
du 12-14 novembre, 1986
Moncton, Nouveau Brunswick

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A special thanks is due to Dr. H. A. Regier for his thoughtful philosophical and informative talk at the banquet.

The proceedings were completed with the support of the Department of Biology, Université de Moncton, Fish and Habitat Management Branch, Department of Fisheries and Oceans, Ottawa.

The reviewed and edited papers are soon going to be published in the special edition, under the series: "Advances in Environmental Science and Technology"of Wiley-Interscience.

PREFACE

This report is the Proceedings of the Thirteenth Annual Aquatic Toxicity Workshop, held in Moncton, New Brunswick from November 12-14, 1986.

The Aquatic Toxicity Workshop is one of a continuing series of annual workshops in Canada on aquatic and environmental toxicology, covering topics from the principles of aquatic toxicology to applications in environmental effects monitoring setting of toxicity criteria in regulations and guidelines, and the development of water quality objectives. The Workshop emphasizes an informal exchange of ideas and knowledge on the topic among interested persons from industry, governments, consulting firms and universities. The Workshop provides an annual focus in Canada on the principles and approaches in aquatic toxicology, and the role of aquatic toxicology in the prevention and control of water pollution.

The Workshop is run by an incorporated National Steering Committee, and the proceedings are published annually with the support of the Department of Fisheries and Oceans.

Papers and posters were sollicited on topics relating to research in aquatic toxicology. Fifty papers (47 oral and 3 poster) were presented and the topics covered a number important areas: acid rain, metals and radionuclides in aquatic organisms, biological availability and effects of particle bound contaminants, pesticides in forestry and agriculture, fish epidemiology and pollution effects on aquatic biota, aquatic toxicity to fish, sediment toxicity testing, aquatic toxicology and the management of marine environmental quality, and environmental assessment.

Editor's Comments

This volume contains abstracts or extended abstracts of the papers, special addresses by distinguished guests and summaries of the special workshop sessions together with the author index and a list of participants. The abstracts were reviewed by the steering committee members and were not subjected to the external view. Comments on any aspects of the contribution should be directed to the authors. Discussions on presentations if any, were included. Some of the tape recordings were not clear and many participants did not turn in their discussion slips. As far as possible, the discussions were edited and included.

1st Row (L to R): Dr. M. Waldichuk and Dr. H.A. Regier

2nd Row (L to R): G.H. McCormick, Y. Poussart, J.S.S. Lakshminarayana, P.J. LeBlanc, R. Van Coillie, N.Y. Khan, G. Ozburn, G. Geen, and G. Westlake.

Session 1. ACID RAIN - CURRENT RESEARCH
PLUIES ACIDES - RECHERCHE ACTUELLES

LEBLANC, P.J. and T. POLLOCK. Chairpersons

SURVIVAL, BLOOD OSMOLALITY AND GILL HISTOLOGY RESPONSES OF YELLOW PERCH, ROCK BASS, BLACK CRAPPIE AND LARGEMOUTH BASS TO ACIDIFIED SOFT WATER, J. Howard McCormick (1), Kathleen M. Jensen (2), and Richard L. Leino (3)

Research at the U.S. EPA Environmental Research Laboratory-Duluth provided acid sensitivity data for the juvenile stage of four freshwater fishes. Fish exposed to acidified soft water ranging from pH 4.5 to 7.0 were able to maintain blood osmotic homeostasis for up to 30 days. At pH 4.0 death ensued. At pH 4.0 largemouth bass died within 9 days, black crappie within 16 days and a rock bass within 27 days. Although yellow perch survived 58 days, they were emaciated and near death.

Blood osmolality and gill morphology were used to monitor well-being. A drop in osmolality to near 200 mmol/kg occurred a few days before death. Prompt removal of acid stress produced nearly complete recovery. Gill hyperplasia precedes life threatening blood osmolality changes and may serve as an early warning indication of adverse effects.

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Des travaux de recherche menés au U.S. EPA Environmental Research Laboratory de Duluth ont produit des résultats concernant la sensibilité à l'acide chez les stages juvéniles de quatre poissons d'eau douce. Les poissons exposés à de l'eau douce acidifiée dont le pH variait de 4.5 à 7.0 furent capables de maintenir l'homéostasie osmotique sanguine pendant au moins 30 jours. A un pH de 4, l'achigan connu la mort en dedans de 9 jours, la marigane, 16 jours et le bar, 27 jours. Même si la perche a survécu pendant 58 jours, le poisson était après ce temps émacié et près de la mort.

L'osmolalité sanguine et la morphologie des branchies furent utilisées pour déterminer l'état de santé des poissons. Une diminution dans l'osmolalité à environ 200 mmol/kg se produisit quelques jours avant la mort. Lorsque le stress acidique fut enlevé, les poissons se rétablirrnt. Une hyperplasie des branchies précède les changements dans l'osmolalité sanguine et ceci peut servir d'indicateur de conditions adverses.

Paper: SURVIVAL, BLOOD OSMOLALITY AND GILL HISTOLOGY RESPONSES OF YELLOW PERCH, ROCK BASS, BLACK CRAPPIE AND LARGEMOUTH BASS TO ACIDIFIED SOFT WATER

Speaker: J. Howard McCormick, U. S. EPA, Duluth, MN

John Gunn, Ontario Ministry of Natural Resource: This seems to be an extremely low pH that you are predicting to cause fish mortality in such systems. Are there such systems in that area that would have natural conditions of that low pH?

McCormick: I don't really know whether such natural systems exist in that area. We expect as the pH of the Rock Lake is lowered that we will lose some largemouth bass before the other three species. We would be able to go in and sample fish from the lake and look at the blood osmolality and gill morphology and from that predict that the animals well-being.

Chris Morry, Fish Habitat Division, D.F.O., Moncton: Is gill damage observed permanent or will total recovery occur?

McCormick: I suspect recovery will be total with time.

N. J. Hutchinson, Dorset Research Center, Ontario, Ministry of Environment: Do your research plans call for examination of early life stage sensitivity to H-ion addition to the physiological stresses of H-ion on adult fish? Early life stage sensitivity would move your effective pH level upward from pH 4.0.

McCormick: The Little Rock Lake acidification encompasses the entire aquatic system. Early life stage sensitivity of these 4 species will be examined and we are doing a study of chronic toxicity of H-ion to fathead minnows.

N. J. Hutchinson: Will you be following the recruitement of the largemouth ass and the black crappie in the Little Rock Lake?

McCormick: Yes, we are following recruitment of these fishes. We have a limnologist and a chemist who are looking at zooplankton, phytoplankton, zoobenthos, emergent vegetation and fish. We also have a hydrologist looking at the weather and water movements through the lake. We want to relate the above observations to the fishes. We also would like to know: must we study all these things? Can we study a portion of the above or only the fish or may be only the fish reproduction. Well, we are going to look at them all and sort out.

BEHAVIOURAL RESPONSES OF LAKE CHARR (SALVELINUS NAMAYCUSH) EMBRYOS TO SIMULATED ACIDIC RUNOFF CONDITIONS: J. M. Gunn, D. L. G. Noakes and G. F. Westlake, Fisheries Branch, Ontario Ministry of Natural Resources, Toronto, Ontario M7A 1W3, Department of Zoology, University Guelph, Ontario N1G 2W1, Aquatic Contaminants Section, Ontario Ministry of the Environment, 125 Resources Road, Rexdale, Ontario M9W 5L1

EXTENDED ABSTRACT

Lake charr (Salvelinus namaycush) spawn over clean broken rubble in shallow (<2 m) nearshore areas. In low alkalinity lakes where severe pH depressions accompany snowmelt, embroyos within the rubble can be exposed to pulses (1-5 d duration) of runoff water containing toxic concentrations of H^+ and inorganic Al. Little is known about behavioural responses that may protect embryos from toxic runoff water. This study was carried out to determine whether lake charr embryos avoid low pH and elevated Al by increased and/or directed locomotor activity.

Locomotor activity was tested in (1) Open Field Dishes; (2) Counter Current Tanks; and (3) Vertical Substrate Tanks (fig. 1, 2, 3). The three test procedures represented a progression towards simulation of the natural conditions existing within the spawning site rubble during snowmelt. All tests were conducted using soft water (Ca 2.0 $mg \cdot L^{-1}$, Na 1.5 $mg \cdot L^{-1}$, cond 25 $uS \cdot cm^{-1}$, hardness as CaCO 5 $mg \cdot L^{-1}$). Experimental fish were acclimated to both the low ionic strength soft water and the test temperatures (1-8 °C), prior to use.

In the open dishes the embryos became hyperactive when exposed to pH 4.0, pH 4.5, and pH 4.5 + 200 ug $Al \cdot L^{-1}$. Exposure to toxic conditions generally produced a brief (0.5-2.0 min) burst of increased (2-4x) swimming speeds, followed by a longer period of inactivity. Many fish responded to the changing chemical conditions by staying in the corners where they would swim vigorously without achieving any lateral movement.

Embryos in the later stages of yolk absorption avoided water with a pH <6.0. The addition of inorganic Al (≤ 200 $mg \cdot L^{-1}$) did not increase the avoidance response to low pH (4.5, 5.0) alone. Early embryos, those just after hatch, had little swimming ability, and remained in the shelter of the substrate pieces at the ends of the counter current tanks, even in acutely lethal conditions (pH 4.0).

Lake charr embryos in the vertical tanks displayed the descent behaviour typical of salmonids. There was no significant effect on survival, or distribution of embryos within the substrate, of short pulse (8 hr) exposure to low pH (4.5) and elevated Al (0, 100, 200, 500 $ug \cdot L^{-1}$) solutions. Under the most severe conditions (pH 4.5, 500 ug $Al \cdot L^{-1}$) embryos ceased movements during the latter part of the 8 hr pulse exposure. Preference for contact with the substate appeared to override the avoidance response observed in the other tests. This thigmotaxis, as well as the characteristic negative phototaxis of embryonic lake charr, appears to eliminate the possibility that lake charr embryos can effectively avoid acidic runoff water.

Des tests en laboratoire ont été effectués afin de déterminer si l'embryon de S. namaycush évitait un pH faible ou un taux élevé de Al par une augmentation et/ou orientation des actvités locomotrices. Une série d'épreuves furent utilisés, allant de tests de mouvements horizontaux à des changements dans

la distribution verticale dans des réservoirs couverts de substrat. Tôt après l'éclosion, les jeunes embryons démontrèrent peu d'habileté à éviter les conditons léthales. Les embryons plus âgés démontrèrent des réactions d'hyperactivité et de comportement d'évitement envers une eau acide ($pH<5.0$). En présence de substrat, les movements horizontaux et verticaux étaient moindres et le potentiel d'évitement effectif éliminé. La température de l'eau (1-10 °C) n'avait aucun effet significatif sur les réponses des embyons. Les alevins libres démontrèrent des préférences thermiques qui semblaient surpasser les réponses d'évitement au milieu acide.

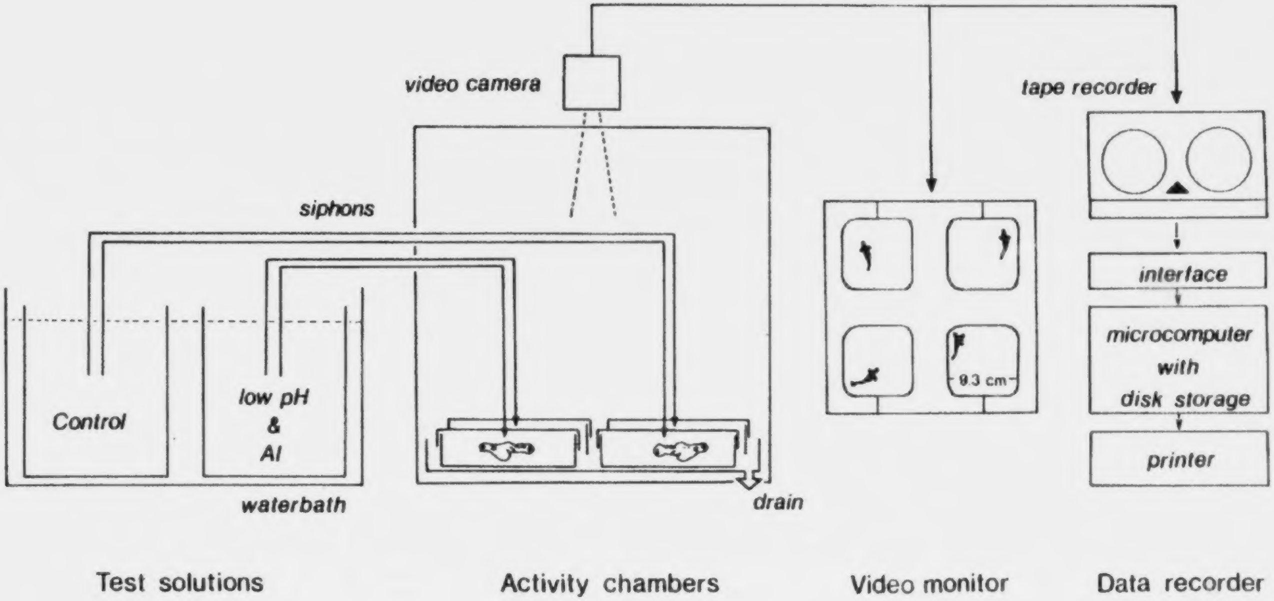


Figure 1. Open Field Activity Test. Swimming behaviour of lake charr embryos was recorded on video tape and speeds calculated with a computer assisted digitizing program. Treatment fish received 200 ml•min^{-1} of control water for 10 min, followed by 10 min of low pH and elevated Al water.

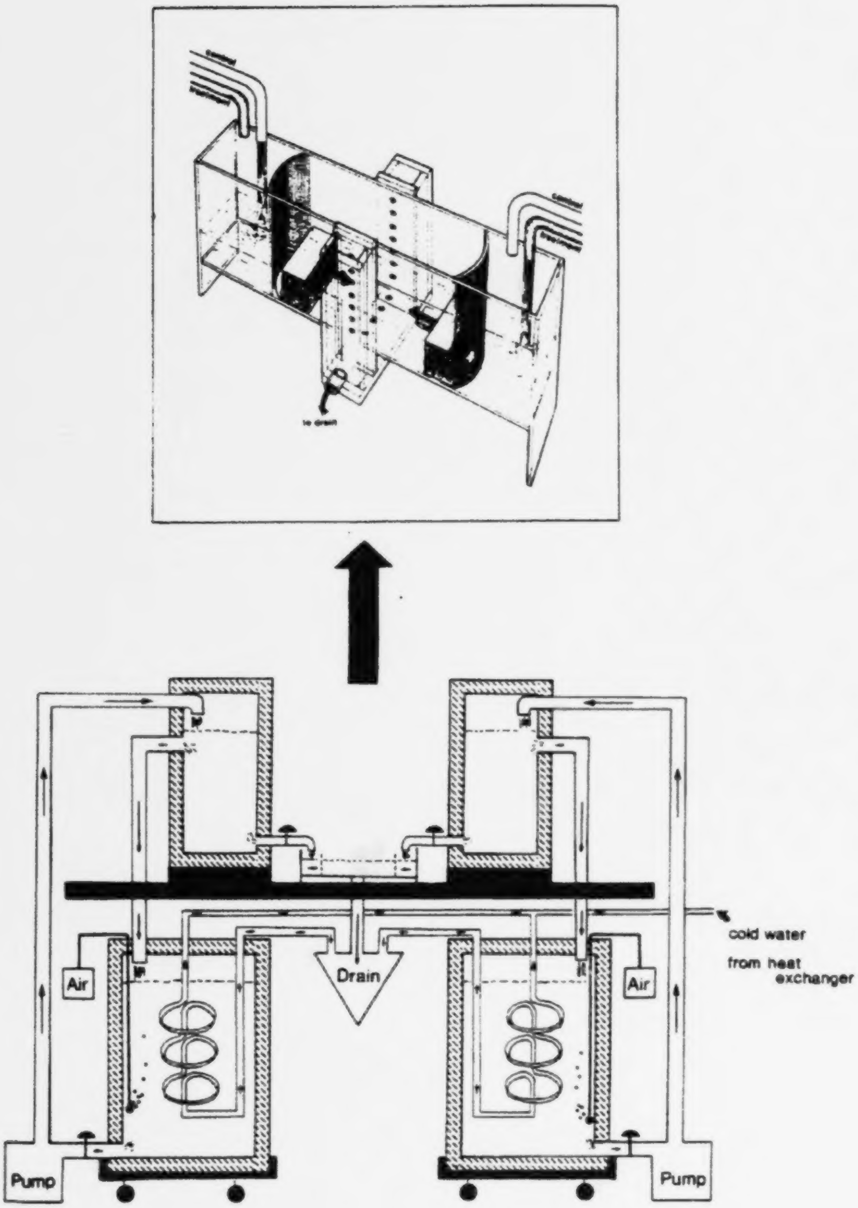


Figure 2. Counter Current Tank. At the start of a test, equal numbers (6) of embryos were placed behind the small pieces of plastic substrate at the end of the 21 cm long chamber. After 3 mins of control water, the water quality on one randomly selected side was changed. The final location of embryos was determined at the end of a 10 min test period.

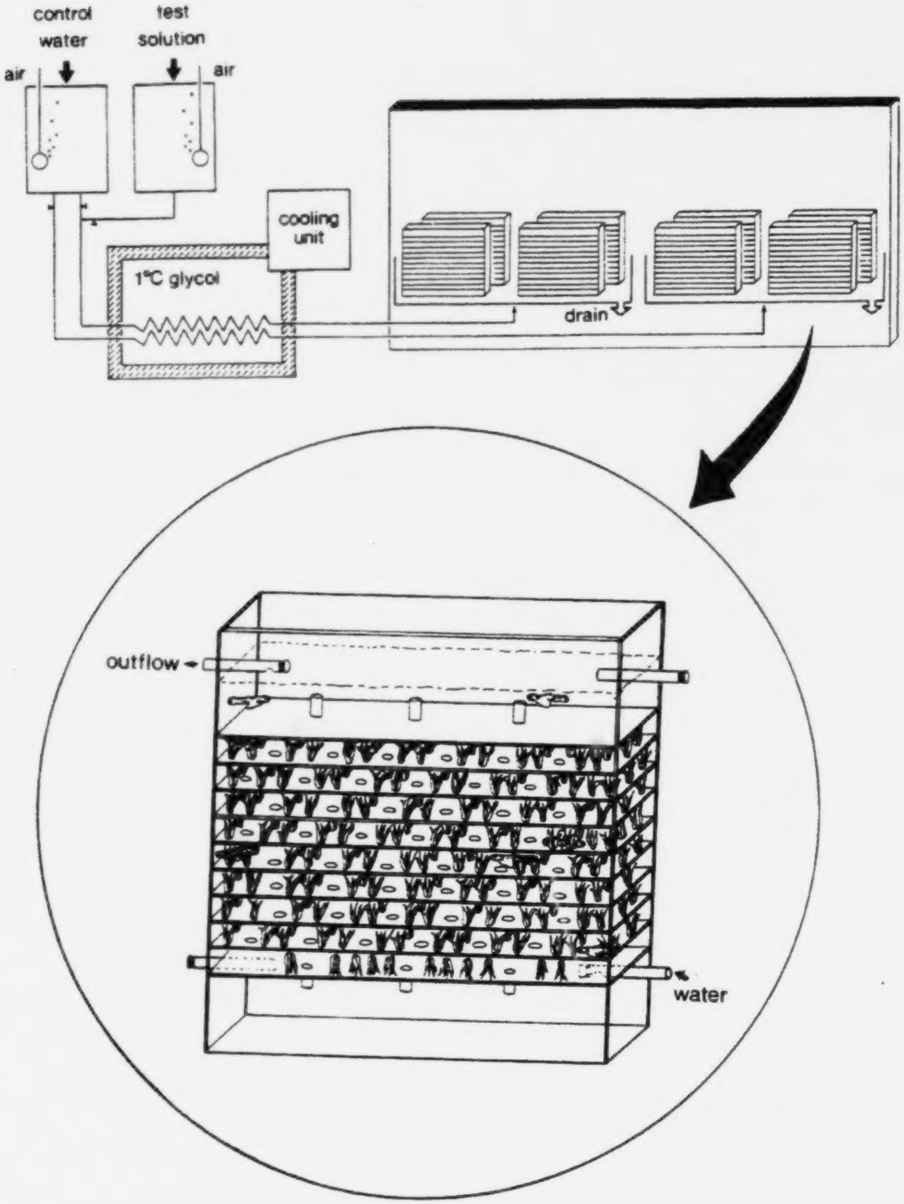


Figure 3. Vertical Substrate Tanks. On 5 occasions during the 84 d experiment, selected tanks (45 x 5 x 45 cm) received a 8 hr pulse of low pH (4.5) and elevated Al (0, 100, 200, 500 $ug{\bullet}L^{-1}$). Depth distributions of embryos within the porous layers of Astroturf were determined before and after each pulse exposure. Movements of embryos during the exposure were also observed.

Paper: BEHAVIOURAL RESPONSES OF LAKE CHARR (Salvelinus namaycush) EMBRYOS TO SIMULATED ACIDIC RUNOFF CONDITIONS

Speaker: John Gunn, Ontario Ministry of Natural Resources.

Keith Holtze, Ontario Ministry of Environment Dorset Research Center: I was just wondering in cases where we have species which we know are being impacted by widely fluctuating conditions, typical spring melt in situations, how do we come up with the field based estimate on the lake pH and what effect is going to occur? Normally where we look for responses in the field the ultimate estimate is based on the average lake conditions. But certainly for species like lake trout and brook trout, they just won't match.

John Gunn: It's a really troublesome thing, this is the concern that somewhat I'd showed you at first I showed that this site specific chemistry is so enormously variable. The chance that the fish choose a vulnerable site, the chance that they are site specific and that the embryos would be exposed at their critical life stages, the chance that I eliminated one they would not avoid or they would avoid, the chance that the lethal conditions would be achieved and finally the overwhelming one that the chance of that natural density compensatory mechanism would not protect the population from small site specific mortality, all these make it very difficult to state that episodic effects were driving populations and those are the hardest things to model. It seems there is still sufficient data that there is chronic conditions out there as well that particularly species like brook trout and that we have to understand the mechanisms far beyond what we are talking of acute conditions here. At pH greater then 5, we still have population collapses. It is difficult to put all your eggs in one basket. At short intervals at sensitive life stages there are generally high mortalities. Anyway, there could be huge buffering capability at the population regulatory level and the collapse of populations are quite unlikely. So the challenge to get out into more realistic conditions of higher pHs, introduces the aluminum concerns that exists under more static conditions and bring some realism into the tests with challenges such as swimming. None of the tanks studies are using exercise at all. We're not looking at carry over effects into progeny. We're not looking at a lot of the population level concerns so I don't know the question anymore, except to focus entirely on the early life stage and being entirely hung up on needing to know that specific chemistry. First thing is hopeless case. We can never understand the lakes enough to know what the chemistry was. To me it doesn't seem necessary, there is still enough action out there beyond the acute toxicity stage that are causing population crashes. So let's forget about the easy, simple early life stage stuff.

Keith Holtze: There are some bio-energetics involved in your work that has considered to predict how long they could survive at a particular pH, and miss the fact that though they survive, they have expended in a due amount of that stored energy that could be a problem in the future for them.

John Gunn: Only, we do in an associated parts of the study there are a lots of findings that show that lethal things happen in terms of metabolic demands and ultimate affects on size and energy reserves. But when you go to the field data again one common feature you see in field population is good growth. Then we're generally talking of abundant food, we're generally talking probably some really interesting condition effects. Acclimations and recovery type things that you've seen probably accomodating a lot of the stress that exist out there and allowing them to maintain themselves to some end point and there may be a very critical cut off point that you need to make the whole lake acutely lethal before we lose these populations. But there does seem to be a great potential for the quitters to acclamate and to recover and there's an enormous potential for the populations to accomodate losses of young individuals.

THE INFLUENCE OF HYDROGEN AND ALUMINUM IONS ON EGGS AND FRY OF LAND-LOCKED SALMON (*Salmo salar ouananiche*).

Annette Huot and Patsy-A. Thompson , Technique du Milieu Naturel, Cégep de St-Félicien, P. Qué. Canada, G0W 2N0

In vitro experiments with indigenous *Salmo salar ouananiche* eggs and frys revealed that unhatched eggs were more sensitive to acid pH's (pH 4.0 and 5.0) than recently hatched frys. At pH 4.0, 26% of the eggs did not hatch and 100% of the unhatched eggs died when they were returned to pH 7.0. Hyperventilation followed by hypoxia was observed in both eggs and frys at pH 4.0 and 5.0. This respiratory stress was accompanied by a gradual decrease in ATP. Tissue acidification and loss of sodium were also observed under these conditions. At pH 4.0 this perturbed metabolism resulted in a lowered growth rate. In a second experiment with aluminum ions (300 ug.l^{-1}), significant delays in hatching were observed. For example after 7 days of incubation, 100% hatching occurred at pH 6.5 compared to 75% at pH 6.5 with Al and 15% at pH 5.0 and pH 5.0 with Al. Eggs exposed to pH 5.0 with Al during 14 days had a 50% mortality rate when transferred to neutral pH with Al. This delayed mortality was not observed with frys where 100% mortality occurred at pH 5.0 with Al. Growth (length) was significantly reduced at pH 5.0 and pH 5.0 with Al. The environmental significance of these results will be discussed with regards to ouananiche spawning in the Aux-Saumons river (Lac St-Jean, Qué.).

Des expériences *in vitro* avec des oeufs et des alevins de la ouananiche indigène (*Salmo salar*) ont révelé que les oeufs non-éclos étaient plus sensibles aux pH acides (pH 4.0 et 5.0) que les alevins récemment éclos. A un pH de 4.0, 26% des oeufs n'ont pas éclos et 100% des oeufs non-éclos sont morts lorsqu'ils furent retournés à un pH de 7.0. L'hyperventilation suivi d'une hypoxie fut observée dans les oeufs et les alevins à un pH de 4.0 et 5.0. Ce stress respiratoire fut accompagné par une diminution graduelle en ATP. L'acidification de tissu et une perte de sodium furent également observées sous ses conditions. A un pH de 4.0, ce métabolisme perturbé amena un taux de croissance plus faible. Lors d'une deuxième expérience avec des ions d'aluminium (300 ug.l^{-1}), des retards significatifs dans l'éclosion furent observés. Par exemple, après 7 jours d'incubation, une éclosion de 100% eut lieu à un pH de 6.5 comparativement à 75% à un pH de 6.5 avec Al et 15% à un pH de 5.0 et un pH de 5.0 avec Al. Des oeufs exposés à un pH de 5.0 avec Al pendant 14 jours avaient un taux de mortalité de 50% lorsqu'ils étaient transférés à un pH neutre avec Al. Ce délai de mortalité ne fut pas observé chez les alevins où une mortalité de 100% eut lieu à un pH de 5.0 avec Al. Une réduction significative de croissance (longueur) fut observé à un pH de 5.0 et un pH de 5.0 avec Al. Les significations environnementales de ces résultats seront discutées en ce qui concerne le frai des ouananiches dans la rivière aux-saumons (Lac St-Jean, Québec).

Paper: THE INFLUENCE OF HYDROGEN AND ALUMINUM IONS ON EGGS AND FRY OF LAND-LOCKED SALMON (*Salmo salar ouananiche*)

Speaker: Patsy-A. Thompson, CEGEP de St-Félicien, Québec, Canada

John Gunn, Natural Resources, Ontario: How do you measure respiration?

P. Thompson: Respiration was measured with a Gilson respirometer.

John Gunn: As eggs?

P. Thompson: Eggs or frys, the results I have show today are for frys which were either recently hatched or 30 days old. The result of the eggs, I haven't brought them with me today.

John Gunn: Would you predict that eggs would do the same respiration?

P. Thompson: The same pattern is observed with eggs also. What I presented today were all for frys and the results we have for eggs is about the same pattern. Hyperventilation is associated with an increase in ATP and hypoventilation with a decrease in ATP. The data we have for aluminum shows that there is a 100% mortality at the pH5 in older frys with aluminum and ATP content goes down really dramatically in those fish just prior to that.

John Gunn: Your calcium and sodium values were what?

P. Thompson: I can't remember.

John Gunn: Was it lab reconstituted water?

P. Thompson: Yes

Harry Cormier, Holland College: Is there any particular reason why you are studying aluminum with pH. Why not cadmium?

P. Thompson: The chemistry, the work we've done on that river shows that iron and aluminum are the main ions that go up in concentration during the spring. Aluminum is known to be toxic to the fish, so that is the reason we used that ion. At pH5, the aluminum is more available than at 6.5 entirely on the early life stage and being entirely hung up on needing to know that specific chemistry. First thing is hopeless because we can never understand the lakes enough to know what the chemistry was. To me it doesn't seem necessary, there is still enough action out there beyond the acute toxicity stage that are causing population crashes. So let's forget about the easy, simple early life stage stuff.

INHIBITION BY LOW pH OF CADMIUM ACCUMULATION IN THE CRAYFISH *ORCONECTES VIRILIS* IN EXPERIMENTAL FIELD ENCLOSURES.

P.S.S. Chang*, D.F. Malley, J.F. Klaverkamp and S.G. Lawrence, Department of Fisheries and Oceans, Freshwater Institute, 501 University Crescent, Winnipeg, MB, Canada. R3T 2N6

Two experiments on the effects of low pH on the accumulation of cadmium by the crayfish *Orconectes* were conducted in 1 m diameter enclosures at the Experimental Lakes Area, northwestern Ontario. In the first experiment, crayfish were held in cages and introduced into enclosures treated with Cd-109 at pH 6.7, 5.4 and 5.0. Some of the enclosures were also enriched with selenium (10 ug.L^{-1}) or calcium (5 and 15 mg.L^{-1}). Low pH consistently retarded accumulation of Cd-109 in crayfish tissues over the period of 35 days. Selenium had no effect on the accumulation of Cd-109 in tissues whereas elevated calcium concentrations were associated with a few cases of retarding Cd-109 bioaccumulation. In the second experiment, crayfish were exposed to 1 and 3 $\mu g.L^{-1}$ of non-radioactive cadmium and held in enclosures at pH 6.7 and 5.3 over a period of 26 days. Crayfish tended to accumulate lower concentrations of cadmium in acidified water (pH 5.3) than in circumnatural lake water (pH 6.7). We conclude that low pH inhibits Cd accumulation by crayfish.

Key words: low pH; cadmium; crayfish tissues; bioaccumulation.

Deux expériences sur l'effet du pH faible sur l'accumulation de cadmium par l'écrevisse *Orconectes virilis* ont été faites dans des enclos de 1m de diamètre à l'Experimental Lakes Area, dans le nord-ouest de l'Ontario. Dans la première étude, les écrevisses étaient gardés dans des cages et placés dans des enclos traités avec du Cd-109 à des pH de 6.7, 5.4 et 5.0. Certains enclos étaient aussi enrichis avec du sélénium (10 ug-L^{-1}) ou du calcium (5 et 15 mg-1^{-1}). Le pH faible retarde de façon consistante l'accumulation du Cd-109 dans les tissus de l'écrevisse sur une période de 35 jours. Le sélénium n'a eu aucun effet sur l'accumulation du Cd-109. Dans la seconde expérience, les écrevisses ont été exposés à 1 et 3 $\mu g-L^{-1}$ de cadmium non-radioactif et gardés dans des enclos à des pH de 6.7 et de 5.3 sur une période de 26 jours. Les écrevisses ont tendance à accumuler moins de cadmium en eau acidifiée (pH 5.3) qu'en eau de lac naturelle (pH 6.7). Nous concluons que le pH faible inhibe l'accumulation de Cd par l'écrevisse.

Paper: INHIBITION BY LOW pH OF CADMIUM ACCUMULATION IN THE CRAYFISH ORCONECTES VIRILIS IN EXPERIMENTAL FIELD ENCLOSURES

Speaker: P. S. S. Chang, Dept. of Fisheries and Oceans, Winnipeg, Canada

Chris Morry, Fisheries and Oceans: On your last point, your last conclusion is this to say that during the period of acidification that there is more cadmium dissolved in the water column or available in sediments than was previously the case in those lakes in there. This will be an enhancement or an aggravation of cadmium uptake by the cray fish or just going back to the normal situation.

P. S. S. Chang: Do you mean during acidification?

Chris Morry: In the recovery period, after a acidification, you are saying that you may then see once again some higher body burdens of cadmium in the cray fish. Is this back to normal levels or beyond the normal levels?

P. S. S. Chang: It is probably beyond normal levels, we don't know, but we just hypothesize this when the lake recovered. we're talking about nature recovery, and when pH goes up cadmium will be more available to the cray fish and absorb more cadmium than during acidification time.

Chris Morry: During the period you were doing these studies, they were all done in enclosures weren't they?

P. S. S. Chang: Right.

Chris Morry: But were there any wild experiments in the wilds to parallel these?

P. S. S. Chang: No, but we are planning to do a whole lake cadmium experiment next spring so probably we'll have some results in the wilds on the whole lake system.

Chris Morry: Do these results indicate that Cd uptake during recovery phase is actually enhanced beyond normal levels or simply return to normal.

P. S. S. Chang: We believe that this increase in Cd accumulation in the recovery phase is simply a return to normal.

THE EFFECT OF pH ON TOXICITY OF SINGLE AND COMBINED METAL MIXTURES (COPPER, ZINC, AND LEAD) TO A FRESHWATER GREEN ALGA,

M.E. Starodub and P.T.S. Wong. Canada Centre for Inland Waters, Burlington, Ont., Canada. L7R 4A6

The influence of pH on toxicity of three metals (Cu, Zn, and Pb) singly and in combination to growth of the green alga *Scenedesmus quadricauda* was investigated. Interactive effects between these metals were assessed. *S. quadricauda* was cultured in CHO-10 media, pH 4.5, 6.5, 8.5) in the presence of individual and metal mixtures and incubated under continuous illumination, 108 $\mu E/m^2/sec$, for a 15 day period. Optical density readings, 665 nm, Bausch and Lomb Spectronic 20, were recorded daily. The relative toxicity of single metals to growth of *S. quadricauda* was Cu > Zn >> Pb. In general toxicity of individual and multiple metals to *S. quadricauda* increased with increased acidity. Synergisms amongst Cu, Zn, and Pb were more prevalent at low pH although variations in metal interactions were observed depending on the model used to analyse combined metal toxicity data. Specific metals, their respective concentrations and pH influence both individual and multiple metal toxicities.

Keywords: *Scenedesmus quadricauda*, pH, single and multiple metals, interactive effects, synergism.

L'influence du pH sur la toxicité de 3 métaux (Cu, Zn et Pb), seuls ou combinés sur la croissance de l'algue verte *Scenedesmus quadricauda* fut étudiée.

Les effets interatifs entre les métaux furent évalués. *S. quadricauda* fut cultivé dans un milieu CHO-10 (pH 4.5, 6.5, 8.5) en la présence de métaux, seuls et mélangés, puis incubés sous une lumière constante, 108 $\mu E/m^2/sec$, pendant une période de 15 jours. La lecture de la densité optique fut effectuée quotidiennement à l'aide d'un "Baush et Lomb Spectronic 20" à 665 nm.

La toxicité relative d'un métal seul sur la croissance de *S. quadricauda* était Cu > Zn >> Pb. En général, la toxicité d'un métal seul ou en mélange sur *S. quadricauda* augmente avec une augmentation de l'acidité.

La synergie touchant le Cu, le Zn et le Pb est plus couranteà un pH bas quoique des variations dans l'interaction des métaux furent obtenues en fonction du modèle utilisé pour analyser les données. Les métaux spécifiques, la concentration respective et le pH influence en même temps la toxicité des métaux seuls et combinés.

Paper: THE EFFECT OF pH ON TOXICITY OF SINGLE AND COMBINED METAL MIXTURES (COPPER, ZINC AND LEAD) TO A FRESHWATER GREEN ALGA

Speaker: M. E. Starodub, Canada Centre for Inland Waters, Burlington, Canada

H. Cormier, Holland College: Were all the experiments done in the laboratory?

M. Starodub: Yes, they were all performed in pyrex tubes in the laboratory.

H. Cormier: Did you take any samples from the lake, the Harbour area?

M. Starodub: No, that wasn't part in this particularly study.

H. Cormier: Is there any reasons why you added more lead and zinc?

M. Starodub: Yes, the concentrations that we choose for the study were based on EC50 values for each respective metal which were determined by primary productivity bioassays.

H. Cormier: What is EC50?

M. Starodub: The concentration that has significant effect.

H. Cormier: Is it like TL50?

M. Starodub: Something like that.

Neil Hutchinson, Dorset Research Centre, Ontario Ministry of Environment: You had apparent synergism with copper and zinc toxicity only at low pH. Did you consider the fact the pH may be action as a joint toxic under that pH instead of just modifying the toxicity of others so that the algae were partly responding to hydrogen ion itself?

M. Starodub: We had controls for each pH that was determined and that at pH 4.5 the control cells grew better.

Neil Hutchinson: They grew better!

M. Starodub: They grew better at a more acid pH and from that you would say that it's definitely toxic affect of the metals.

ACID RAIN, FISH TOXICOLOGY AND HYPOTHESIS TESTING.

N.J. Hutchinson, Dorset Research Centre, Ontario Ministry of the Environment, P.O. Box 39, Dorset, Ontario, Canada, P0A 1E0

In the last 8 years many studies have attempted to explain the disappearance of fish populations from culturally acidified waters. It is still not clear, however, why the pH at which populations disappear in the field is higher than that predicted by lab tests of fish response to H+ and Al. A synthesis of relevant studies is presented to see if we have isolated the correct toxicological identities in the laboratory.

Acute and chronic toxicity of H+ and Al to fish have been extensively studied but the importance of Al has been overestimated by the methods used. Al toxicity requires either unrealistically high concentrations or a-priori H+ stress. Chronic and acute toxicity of trace metal mixtures come much closer to explaining observed losses form lakes in ontario, the U.S.A. and Europe. Recruitment failures can be induced in the lab at levels of Al, Zn, Cu and H+ which are realistic to those observed in situ.

Acute lethality of H+ and metals during spring snowmelt and rainstorms may represent a missing connection between lab and field responses but this hypothesis has not been suitably tested. The best fit between lab and field responses may be: short exposures to high levels of H+ and Al during snowmelt, superimposed upon chronic acidification and its increased metals levels.

Durant les 8 dernières années, plusieurs études ont tenté d'expliquer la disparition de la population de poissons des eaux acidifiées par l'agriculture. Cependant, il n'est pas encore clair pourquoi le pH auquel la population disparaît sur le terrain est plus élevé que celui prévu par les tests de laboratoire de poissons au H^+ et à Al. Une synthèse des travaux déjà executés est présentée pour voir si nous avons isolé l'identité toxicologique correctement en laboratoire.

La toxicité chronique et aiguë de H^+ et Al pour le poisson a été bien étudiée mais l'importance du Al à été surestimée par les méthodes utilisées. La toxicité au Al requiert de grandes concentrations ou a priori un stress de pH. La toxicité chronique et aiguë des traces de mélange de métal vient plus près d'expliquer les pertes observées dans les lacs de l'Ontario, des Etats-Unis et de l'Europe. Une certaine mortalité peut être induite en laboratoire à des taux de Al, Zn, Cu et H^+ qui sont semblables à ceux observés in situ.

L'influence néfaste de H^+ et des métaux durant les fontes de neige et des averses de pluie au printemps, peut représenter un lien étroit entre les réponses servies en laboratoire et sur le terrain, mais cette hypothèse n'a pas été vérifiée convenablement. Le meilleur accord entre les réponses en laboratoire et sur le terrain peut être une courte exposition à de hauts taux de H^+ et Al pendant la fonte de la neige, superposée à l'acidification chronique du milieu et l'augmentation de sa teneur en métaux.

Paper: ACID RAIN, FISH TOXICITY AND HYPOTHESIS TESTING

Speaker: N. J. Hutchinson, Dorset Research Centre, Ontario Ministry of Environment, Canada

Chris Morry, Fisheries and Oceans: Getting a little bit out of the scientific end of this, but staying within the realm of hypothesis testing, what is your personal theory as to why aluminum has turned out to be the culprit in so many studies and why other metals have been ignored for so long.

N. J. Hutchinson: Well, if you look at the field surveys from both recent ones and the original surveys from Norway, hydrogen ions always emerged as a factor governing fish presence or absence or distributions. You could explain most of your variation in fish distributions with hydrogen ions alone and aluminum added a bit more of an affect to that. As far as the ignorance of the other metals, aluminum was brought up because it's concentration are high and it fluctuates widely and people seem to just have jump on it and follow it. I think it's because nobody tested or looked at anything else. The original classic paper by Dick Beamish suggested from the start that metal mixtures were probably of importance. For some reason the first toxicity tests ever done were done with aluminum and everybody followed that.

C. Morry: Despite the fact that Beamish himself didn't look at aluminum!

They weren't even measuring aluminum in those days. It has been the latest studies that have actually started measuring them. But since they started measuring them, they conveniently forgot everything else. The original proceedings at the Cornell Conference went through aluminum, maganese, zinc and said that we consider all these and we decided to study aluminum. That was the rational.

J. Gunn, Ontario Ministry of Natural Resources: We won't bring up the old items, but I think we should let the people be aware of the Sudbury smelt metal feature is enormous, if not all, the effects in North America are in that area. So literature is driving by a smelter influence and you still have to put in the Norwegian perspective where aluminum, calcium, sodium values that are half your concentrations and half of our American concentrations might again be an important item.

N. J. Hutchinson: Right, I don't deny the importance of the uniqueness of the Sudbury data set to the literature although zinc is also elevated in the Norwegian lakes and lead is also slightly elevated in some of them. Zinc also went into the experimental certification of 2 to 3. Although affects are certainly confined to Sudbury region and it's somewhat unique, there are other areas where similar things are happening.

Bill Gibson, Trent University: Christine Nevelle has pointed out or at least she believes there are two mechanisms of aluminum toxicity, one at over-saturation and one below-saturation. One of your slides, the only one where we actually seen them in concentrations today. You had 300 and 1000 mg per l of aluminum until you get to the really low pH. To begin with 300 is still over-saturated. I was just wondering if you can speculate what was going on with the under-saturation mechanism?

N. J. Hutchinson: At pH4.8 300 mg of aluminum is under-saturation and the 1000 mg per litre concentration was all within the saturated range because we are down at pH4.4. But what we've seen this joint action of hydrogen ions in a lot of America requires to dissolve the aluminum. It's an ion regulatory disfunction and the over-saturated concentration we get this suffocation effect by direct aluminum precipitation out of the gills. So it's a valid concern but I think the guiding factor has to be the brisk reserve observation that we don't get aluminum over-saturation *in situ*. When we get high level of *in situ* they are usually organically complexed or particulate aluminum, they are not pure aluminum hydroxides.

B. Gibson: Do you speculate on a little bit higher pH5 and non-saturated aluminum?

N. J. Hutchinson: Well, in our salmon studies we never saw toxicity there. Some of the work Keith Holtze will present we did get toxicity up there and again that would depend if the species was sensitive to hydrogen alone at pH5, you might expect aluminum effect there.

RELATING LABORATORY TESTS OF HYDROGEN ION AND ALUMINUM TOXICITY TO LARGE-SCALE FIELD SURVEYS OF FISH POPULAION LOSSES IN ACIDIFIED WATERS OF EASTERN NORTH AMERICA.

K.E. Holtze and N.J. Hutchinson, Ontario Ministry of the Environment, dorset Research Centre, P.O. Box 39, Dorset, Ontario, Canada P0A 1E0

Acid and Al tolerance limits were determined for 8 fish species including lake trout, brook trout, walleye, white sucker, common shiner, smallmouth bass, largemouth bass and lake whitefish. Results were obtained by continuous flow testing of early life stages in natural soft water (4.0 mg Ca/L). Near 10-fold differences in sensitivity to H+ and Al were observed between species and life stages. The addition of Al did not alter ranking by species in terms of their tolerance to H+ at 5 stages of development. Al however was a significant factor ordering life stage sensitivity. Egg mortality was primarily related to H+ toxicity while Al emerged as a significant contributor to post-hatch mortality with the onset of gill breathing. Zero and fifty percent effect levels, based on the response of the most sensitive stage tested, bracketed the pH of disappearance observed in field surveys for 3 of the 8 species. In 4 of the remaining cases, fish survival and reproduction in the field occurred below lab estimates of the pH producing 50% mortality. For largemouth bass testing was limited to the juvenile stage. For this species, the no effect pH level occurred below that at which populations have been lost in the field.

Keywords: fish, H+ and Al toxicity, early life history stages

Les limites de tolérance à l'acidité et à l'aluminium (Al) ont été déterminées chez 8 espèces de poissons incluant: la touladi, la truite de ruisseau, le doré, le catostome noir, la chatte, l'achigan à petite bouche, l'achigan à grande bouche, et la corréfone (poisson blanc). Cette tolérance fut établie pour les stades précores de vie de ces poissons, placés en eau douce naturelle (4.0 mg Ca/L) en écoulement continu. Des différences de sensitivités au H^+ et à Al allant jusqu'à un ordre de grandeur furent observées entre les espèces et les stages de vie. L'addition de Al n'a pas modifié le rang des espèces en termes de leur tolérance au H^+ aux 5 stages de développement. Par contre, l'Al était un facteur d'importance de la sensitivité chez les différents stages de développement. La mortalité de l'oeuf était principalement reliée à la toxicité à l'H^+ alors que l'Al semble être un contributeur significatif à la mortalité post-embryonnaire. Chez 4 des cas, la reproduction et la survie en milieu naturel se produisent à des pH plus faibles que ceux produisant 50% de mortalité en laboratoire. Pour l'achigan à grande bouche, le testing fut limité aux stades juvéniles. Pour cette espèce, le pH sans effet fut plus faible que celui pour lequel des populations sont mortes en milieu naturel.

Paper: RELATING LABORATORY TESTS OF HYDROGEN ION AND ALUMINUM TOXICITY TO LARGE-SCALE FIELD SURVEYS OF FISH POPULATION LOSSES IN ACIDIFIED WATERS OF EASTERN NORTH AMERICA

Speaker: K. E. Holtze, Ontario Ministry of Environment, Dorset Research Centre, Canada

P. H. Johansen, Queen's University: Precisely what part of the juvenile stage for largemouth bass?

K. E. Holtze: Approximately 3 to 4 months and 3 cm in length.

DO LABORATORY TOXICITY TESTS ADEQUATELY DESCRIBE FISH RESPONSE TO ACIDIFICATION IN-SITU? N.J. Hutchinson, Dorset Research Centre, Ontario Ministry of the Environment, P.O. Box 39, Dorset, Ontario, Canada P0A 1E0

Laboratory testing of lake trout, brook trout and walleye response to H+ and Al was done in conjunction with controlled exposures of the same species in acidified Canadian Shield waters. All fish had similar pre-exposure histories and were tested at equivalent development stages. All chemical measurements were made in the same lab and the same investigators performed field and lab studies. We hypothesized that lab and field results should be directly comparable as most potential sources of error were controlled. Tests in which concentrations of H+, Al and Ca were identical were selected for comparison.

In the majority of comparisons survival in the lab exceeded that in situ. Laboratory tests provided total explanation of survival at low toxicant concentrations, partial explanation at high concentrations and poor explanation at intermediate levels. Possible missing variables are identified for future consideration.

Le testing en laboratoire de la truite de lac, la truite de ruisseau et la réponse doré jaune à H^+ et Al fut effectué en conjonction avec des expositions contrôlées des mêmes espèces dans des eaux acidifiées du Bouclier Canadien. L'historique de pré-exposition de tous les poissons étaient semblables et ils furent testés à des étapes équivalentes de développement. Toutes les analyses chimiques furent effectuées dans le même laboratoire et les chercheurs accomplirent les études de laboratoire et de terrain. Nous avons supposé que les résultats de laboratoire et de terrain devraient être directement comparables puisque la plupart des sources d'erreurs possibles furent contrôlées. Les épreuves dans lesquelles les concentrations de H^+, Al et Ca étaient identiques furent choisies afin de faire la comparaisons.

Dans la majorité des cas, la survivance au laboratoire a excédée les épreuves in situ. Les épreuves en laboratoire ont fourni une explication totale de la survivance à de faibles concentrations de produits toxiques, une explication partielle à de hautes concentrations et une explication pauvre à des niveaux intermédiaires. Des variables possiblement manquantes sont identifiées pour des considérations futurs.

FACTORS MODIFYING LETHALITY OF H-ION AND AL TO SALMONID EARLY LIFE STAGES.

N.J. Hutchinson and K.E. Holtze,
Dorset Research Centre, Ontario Ministry of the Environment,
P.O. Box 39, Dorset, Ontario, Canada P0A 1E0

Lethality of H-ion and Al to egg and fry stages of lake and brook trout was determined in a series of laboratory toxicity tests in soft water.

Mortality of both species was not confined to the exposure period and often continued after transfer to control water following short-term exposure of eggs and fry. This pattern was apparent even when lethal thresholds were reached during exposure. Post-exposure mortality reduced survival of lake trout eggs from 90% after 7d exposure at pH 4.0 to 40% by hatch and 3% at 7d post-hatch.

Al toxicity is dependent on a-priori H-ion stress or concentrations above solubility. Any pH-related changes in Al toxicity may be more related to H-ion sensitivity of the organism in question and Al solubility, than to changes in speciation of inorganic, monomeric Al.

Decreasing the ionic strength of test water increased the lethality of H-ion and Al. In very dilute waters, Na had as great an influence on fish survival as Ca. Snowmelt and rainstorm events should have little impact on salmonid survival, based on single-pulse exposures to extreme pH/al combinations.

La létalité des ions H^+ et Al^{+++} sur les oeufs et les alevins de la truite de lac et de ruisseau a été déterminé par une série de tests de toxicité en laboratoire.

La mortalité chez les deux espèces n'était pas restreinte à la période d'exposition et souvent se manifestait après le transfert des oeufs et des alevins dans de l'eau contrôle suivant une courte période d'exposition. Ce phénomène fut observé même lorsque le maximum létal fut atteint durant l'exposition. La mortalité après exposition réduisit la survivance des oeufs de truite de lac de 90% à 40% après 7 jours d'exposition à pH 4, et à 3%, 7 jours après la naissance.

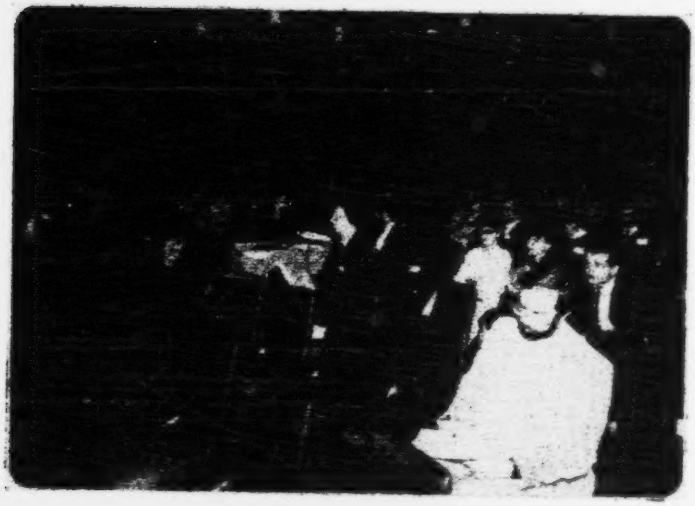
La toxicité de l'Al est, a priori, dépendante du stress causé par l'ion H^+ ou de concentrations au-dessus de la solubilité. Tout changement dans la toxicité de Al relié au pH peut être relié de façon plus directe à la sensibilité de l'organisme en question à l'ion H^+ et à la solubilité de Al, plutôt qu'aux changements dans la spéciation de Al monomérique inorganique. La diminution de la force ionique de l'eau utilisée dans les épreuves, augmenta la létalité des ions H^+ et Al^{+++}.

Dans l'eau très diluée, le Na a autant d'influence sur la survie du poisson que le Ca. La fonte des neiges et l'eau de pluie devraient avoir peu d'influence sur la survie des salmonidés, en se basant sur des expositions ponctuelles de pH et de Al à des niveaux extrêmes.

Session 2. METALS AND RADIONUCLIDES IN AQUATIC ORGANISMS

METAUX ET RADINCLEIQUES DANS LES ORGANISMES AQUATIQUES

VAN COILLIE, R., and S.D. MACKNIGHT, Chairpersons



CONTAMINATION PAR LE MERCURE ET LES BPC DE SEPT BASSINS VERSANTS DU FLEUVE SAINT-LAURENT, QUEBEC.

M. Paul et D. Laliberté. Direction des relevés aquatiques, ministère de l'Environnement, Québec, Canada G1X 4E4

En 1983 et 1985, des campagnes d'échantillonnage ont été menées dans les rivières Châteauguay, du Nord, L'Assomption, Saint-Maurice, Saguenay, Richelieu et des Outaouais dans le cadre des activités du réseau de surveillance des substances toxiques en milieu aquatique du ministère de l'Environnement du Québec. Au cours de ces campages, les sédiments et la chair des poissons benthivores et piscivores ont été récoltés et analysés afin d'en déterminer la teneur en mercure et en BPC.

La contamination mercurielle de la chair de poisson demeure importante pour ces cours d'eau puisqu'en 1983, la norme aximale admissible de 0,5 mg/kg dans la chair de poisson a été dépassée à 29 stations sur 62. Cette situation est surtout due aux teneurs retrouvées dans la chair des prédateurs tel le grand brochet, le doré jaune et l'achigan à petite bouche. En 1985, cette tendnce s'est maintenue avec 16 stations sur 21 présentant des spécimens dont la chair excédait la norme de 0,5 mg/kg. Parmi ces cours d'eau, les rivières des Outaouais et Châteauguay présentent les niveaux de contamination les plus élevées. D'autre part, l'ensemble des résultats de BPC dans la chair de poisson se situe sous la directive administrative de 2 mg/kg et les plus hautes teneurs ont été retrouvées sur les rivières L'Assomption et Saint-Maurice. Ce composé, tout comme le mercure, se retrouve également dans les sédiments analysés.

Mots clés: réseau, contamination, poisson, milieu aquatique, mercure, BPC, sédiments

During 1983 and 1985, sampling was done in rivers such as the Châteauguay, Richelieu and Outaouais while monitoring toxic substances in aquatic environment by the Quebec Dept. of Environment.

During this campaign, sediment and flesh from benthivorous and piscivorous fish were collected and analyzed in order to determine the concentration of mercury and PCB.

Mercury contamination in fish is considerable in these waters since 1983. The acceptable level of 0.5 mg/kg of flesh was exceeded in 29 stations of a total of 62. The high concentration found in the flesh of predators such as the northern pike, the walleye and the small mouth bass are the cause of this situation.

In 1985, this trend was maintained with 16 stations of a total of 21 showing specimens which flesh exceeded the limit of 0.5 mg/kg. Included in these waterways the Outaouais and the Châteauguay rivers showed the highest levels of contamination.

On the other hand, the total results of PCB in the flesh of fish were obtained from the administration of 2 mg/kg and the highest concentration were found in the Assomption and Saint-Maurice rivers. This compound, as well as mercury, was also found in the analyzed sediments.

Paper: CONTAMINATION PAR LE MERCURE ET LES BPC DE SEPT BASSINS VERSANTS DU FLEUVE SAINT-LAURENT, QUEBEC

Speaker: D. Laliberté, Ministère de l'environnement, Québec, Canada

Ray Côté, Dalhousie University, Halifax: How do you use this information, when you have found contamination in the Châteauguay River? How do you use this information? Have investigations been conducted to determine the source of Hg contamination in the Châteauguay River?

D. Laliberté: This information produces a guide for eating fish, to show clients what they should eat and how much they should eat of a certain type of fish. Because in Quebec, we do not disallow fishing in any river, so fishermen can get information about how much fish they can use of a certain species. This brochure is distributed throughout Quebec and it indicates how much you should eat especially for the walleye and the northern pike which are the most contamined species.

Claude Desjardin, Fisheries and Oceans Canada: Have your studies been published and is this publication available?

D. Laliberté: Yes, we published this data in three documents, which give the results. Two documents for 1983 and two other documents for 1985, which are still not available but which will be soon published.

Philip Ross, University of Illinois, U.S.A.: Your analysis of PCB, were they done with complete fish?

D. Laliberté: No, just on the meat of the fish and the muscle.

P. Ross: Did you separate the muscles from the skin?

D. Laliberté: I forgot to mention that, yes, we did our analysis below the dorsal fin, without the skin and without the viscera.

THE EFFECTS OF TEMPERATURE ON WATERBORNE ARSENIC TOXICITY TO RAINBOW TROUT (SALMO GAIRDNERI).

S. M. McGeachy and D. G. Dixon. Dept. of Biology, University of Waterloo, Waterloo, Ontario N2L 3G1

Arsenic is a metalloid element and although it has received much attention as a homicidal agent, it is 10 to 100 times less toxic than most heavy metals. The valence form of arsenic plays a vital role in determining the toxicity of arsenic, and among the common valences, arsenite (As^{+3}) is two to three times more toxic than arsenate (As^{+5}). Levels of arsenic in the aquatic environment can reach concentrations toxic to aquatic organisms. Arsenic enters the aquatic environment through anthoropogenic routes associated with mining activities and natural routes associated with the weathering and leaching of arsenic rich soils such as arsenopyrites, slates and phyllites. Since arsenic is broadly distributed geographically, its toxicity to aquatic organisms can be subjected to a wide range of abiotic and biotic modifiying factors, particularly temperature. Temperature can directly control the metabolism of poikilothermic animals and their response to toxicants.

This research was undertaken to investigate the influence of temperature (5°C and 15°C) on the toxicity of waterborne arsenite (As_2O_3) and arsenate (Na_2HAs_4 $7H_2O$) to rainbow trout (Salmo gairdneri). Groups of 3 g rainbow trout were acclimated to 5°C or 15°C for 2.5 wk prior to acute (120 h) bioassay testing. While trout exposed to arsenate to 5 C were twice as tolerant as trout tested at 15°C (arsenate 120 h LC50: 5°C, 142mg/L; 15°C, 62mg/L), there was no signifiant difference in LC50's when exposed to arsenite (arsenite 120 h LC50: 5°C, 19.6 mg/L; 15°C, 21.0 mg/L). Survival times for trout exposed to arsenate were twice as long when acclimated to the lower (5°C) test temperature (Table 1). This suggests that temperature plays a modifying role with the toxicity of arsenate and not arsenite, and that arsenite is more toxic to rainbow trout than arsenate.

Acute uptake and depuration tests at 0.5 LC50 and 1.0 LC50 levels were performed with arsenate to examine the influence of temperature on arsenate toxicity. Uptake was determined at 48 h and 72 h while depuration was analysed after returning the remaining trout to clear water for 48h. Whole body burden arsenic (mg/kg wet wt) uptake was much greater at 15°C than at 5°C (Figure 1). Whole body burden for trout exposed to 79 mg/L As was twice as high for trout acclimated at 15°C then a 5°C. Also shown in Figure 1, 72 h uptake at 5°C trout exposed to 70 mg/L As (0.5 LC50) was less than the uptake for 15°C trout exposed to 35 mg/L As (0.5 LC50). Hence, it appears that trout acclimated to a lower temperature (lower metabolism) are more tolerant to arsenate because they are taking up less arsenate in the body. Rate of depuration is also greater for the higher temperature trout (49% depuration vs 28% depuration).

Puisque l'arsenic possède une grande distribution géographique, sa toxicité pour les organismes aquatiques peut être modifiée par un grand nombre de facteurs biotiques et abiotiques, dont la température. De plus, les formes arsenicales qui peuvent être présentés, soit l'état "trivalent/ (arsenite) ou l'étâit "pentavalent" (arsenate), ont de différents niveaux de toxicité. Ces travaux nous ont permis d'étudier l'effet de la température (5°C vs 15°C) sur la toxicité de l'arsenite (As_2O_3) et de l'arsenate ($Na_2HAsO_4:7H_2O$) sur la truite arc-en-ciel de 3g acclimates à 5°C ou â 15°C pendant 2.5 semaines avant le test de bioassai aigu (120 h). Les truites exposées à l'arsenate à 5°C

étaient deux fois plus résistantes que celles acclimatées à 15 °C (arsenate 120h LC50: 5 °C, 142 mg/L; 15 °C, 62 mg/L), mais il n'y avait aucune différence significative entre les deux groupes lorsqu'exposés à l'arsenite (arsenite 120h LC50: 5 °C, 196 mg/L; 15 °C, 21.0 mg/L). Des tests d'ingestion et dépuration de ces formes arsenicales à des degrés fatals seront discutés en tentant compte de nouvelles données toxicologiques trouvées dans cette étude.

	ARSENATE		ARSENITE	
	5°C	15°C	5°C	15°C
120hLC50 (mg/l)	142.3*	64.5*	19.6	21.0
(95%CI)	(127-159)	(59-70)	(17.9-21.5)	(19.7-21.7)
Mean wt (g)	3.02	3.06	5.16	4.93
LT50 80mg/L (hrs)	> 144*	60.8*		
LT50 115mg/L (hrs)	> 144*	30.1*		

* denotes significant differences, $p < 0.05$

Table 1. The effects of temperature on the acute toxicity of arsenic rainbow trout acclimated to 5°C and 15°C.

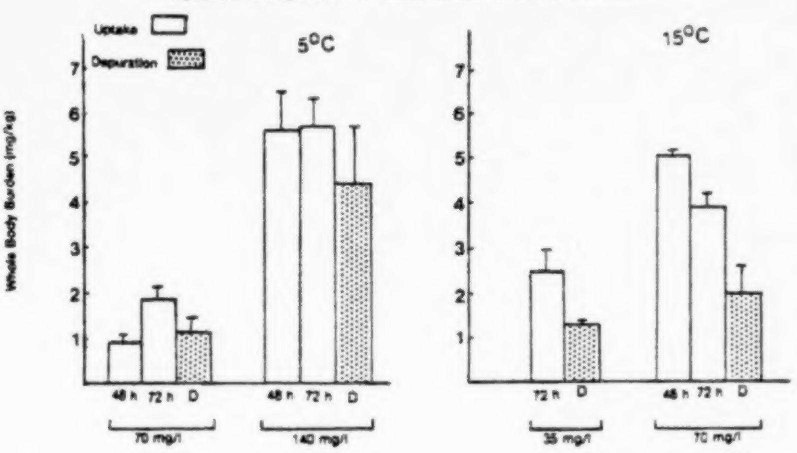


Figure 1. Uptake (72 h) and depuration (48 h) of lethal levels of arsenate by rainbow trout acclimated at 5°C and 15°C.

Paper: EFFECT OF TEMPERATURE ON THE TOXICITY OF WATERBORNE ARSENIC TO RAINBOW TROUT (Salmo gairdneri)

Speaker: S. M. McGeachy , University of Waterloo, Waterloo, Canada

M. C. Mehra, Université de Moncton: What analytical scheme was utilized to estimate arsenic in the system?

S. M. McGeachy: We used column separation for total As and ion exchange for different species of arsenic in the organisms. We determined the absorption by neutron activation method.

M. C. Mehra: You have estimated As^3 and As^5 individually. What shall be the effect on the system if As^3 and As^5 are present at the same time.

S. M. McGeachy: This will be a case of multiple toxicity. First we have to know the individual species of arsenic and then only we can compare the two forms and their effect on the system.

I. Anestis, McGill University: How can you account for the higher uptake of arsenite in fish exposed for 48 hours compared with the uptake after 72 hours exposure at 15°C and 70 mg/l.

S. M. McGeachy: We will run some tests for 24 hrs and try to explain why the uptake progressively peaks at 48 hours.

Stella Swanson, Saskatchewan Research Council: Would you comment on the possibility of increased arsenic toxicity in a lake at spring turnover due to the release of arsenite (As^3) from the anoxic hypolimnion.

S. M. McGeachy: There is a possibility of toxicity to algae and invertebrates. Fish are less sensitive to As. Furthermore, environmental levels would be much lower than those used in this study.

ACUTE AND CHRONIC TOXICITY OF WATERBORNE INORGANIC TRIVALENT ARSENIC TO RAINBOW TROUT (*SALMO GAIRDNERI*), M. G. Rankin and D. G. Dixon, University of Waterloo, Waterloo, Ontario N2L 3G1

Arsenic is a metalloid element occurring ubiquitously in the environment. It is a significant by-product of gold, lead, nickel, copper, iron and steel production. In addition, various arsenicals is an important consideration regarding its toxicity, and of the two most common valencies, (As^{+3}, As^{+5}), the trivalent form is the more toxic species. In addition, the trivalent arsenical, arsenic trioxide (As_2O_3), is the more common anthropogenic emission.

Research was undertaken to address both the acute and chronic toxicity of inorganic trivalent arsenic through aqueous exposure. This was assessed of 14°C using lethal bioassays with both naive fish and previously exposed fish. A four month growth study was also performed using nominal concentrations of 0.5, 2.0 an 8.0 mg/l As^{+3} and pairfed controls, each treatment being replicated three times. In all cases fish were standardized to an initial mean wet weight of 3.0 g. Experimental fish received food *ad libitum* while rations for paired controls were adjusted to match the experimental feed consumption.

Fish (mean wet wt. = 4.25 g) naive to arsenic yielded a 144 hr LC50 of 18.475 mg/l (Table 1). However, fish taken from the four month chronic exposure (wet wt. = 35 g) were apparently more sensitive (144 hr LC50's 14.577 - 15.358 mg/l). In addition, fish reared at 2.0 mg/l As^{+3} were marginally more tolerant than control fish.

There was no significant effect of arsenic concentration on packed cell volume, hemoglobin content, hepatosomatic and splenosomatic index. Final wet weight of fish exposed to nominal concentrations 0.5 and 2.0 mg/l As^{+3} dit not differ from paired controls nor between treatments (Fig. 1). However, 8.0 mg/l caused a significant decrease (37%) in final wet weight when compared to the two lower concentrations. This decrease was marginally non-significant when compared to its paired control and is consistent with the observed poor feeding response evident at the highest concentration.

Whole body arsenic uptake (Fig. 2) suggests that these fish were able to improve depuration with continued exposure. The trend for each exposure level was for a reduction in while body arsenic content beyond the first three weeks of exposure. When converted to a wet weight basis and compared to measure exposure levels, total arsenic content did not exceed a bioconcentration factor of unity (Fig. 3). Interestingly, fish exposed to 0.5 mg/l As^{+3} demonstrated the greatest potential for bioconcentration while those at 8.0 mg/l exhibited the least potential. This suggests a threshold level of arsenic may be required to invoke a depuration mechanism.

Keywords: arsenite acute, chronic, rainbow trout.

L'arsenic est un élement métalloique omniprésent dans l'environnement. C'est un sous-produit significatif des opérations d'exploitation minière de l'or et il est impliqué dans la production de certains herbicides et pesticides. Cette étude vise à déterminer la toxicité aigue et chronique de l'arsenic trivalent inorganique dans l'eau sur les jeunes truites arc-en-ciel. Une mortalité aigue est apparue à des niveaux de 144h LC50 de "ca." 16.5 mg/L. Par ailleurs, une exposition

chronique de quatre mois à des concentrations de 0.5, 2.0 et 8.0 mg/L ont causé une baisse de 50% dans le poids final à 8.0 mg/L, tandis que les deux concentrations plus faibles ont donné des résultats sans différence significative entre les deux doses. Le travail actuel qui traite de l'ingestion, la dépuration et la distribution des métabolites arsenicaux, et leurs effets histologiques seront discutés.

TREATMENT		LC50 (mg/l)	FIDUCIAL LIMITS 95 %	
PRE-EXPOSURE FISH (NAIVE)	REP 1	18.882 a	17.873	19.948
	REP 2	18.110 a	17.422	18.826
	POOLED	18.475 a	17.864	19.107
POST-EXPOSURE FISH				
	0.50 mg/l EXPOSED	15.039 b,c	14.193	15.934
	0.50 mg/l PRD CONTROL	14.577 b	14.334	14.825
	2.00 mg/l EXPOSED	15.358 c	15.133	15.579

a,b,c - differing letters indicate significant differences at P<0.050

Table 1. Summary of 144hr LC50's for rainbow trout exposed to trivalent inorganic arsenic. "Pre-exposure" refers to naive fish and "Post-exposure" refers to fish used from the chronic exposures.

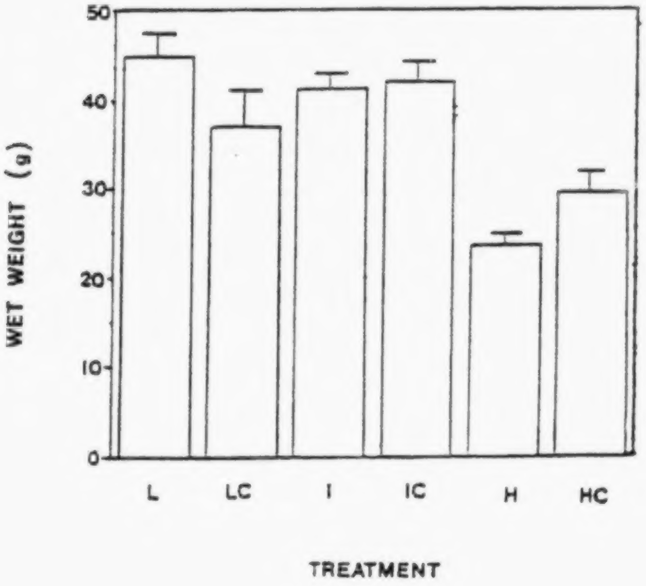


Figure 1. Final wet weights of rainbow trout after 121-day exposure to trivalent inorganic arsenic. Error bars indicate SEM. L, I, H - Low, Intermediate and High concentrations, respectively, C - control.

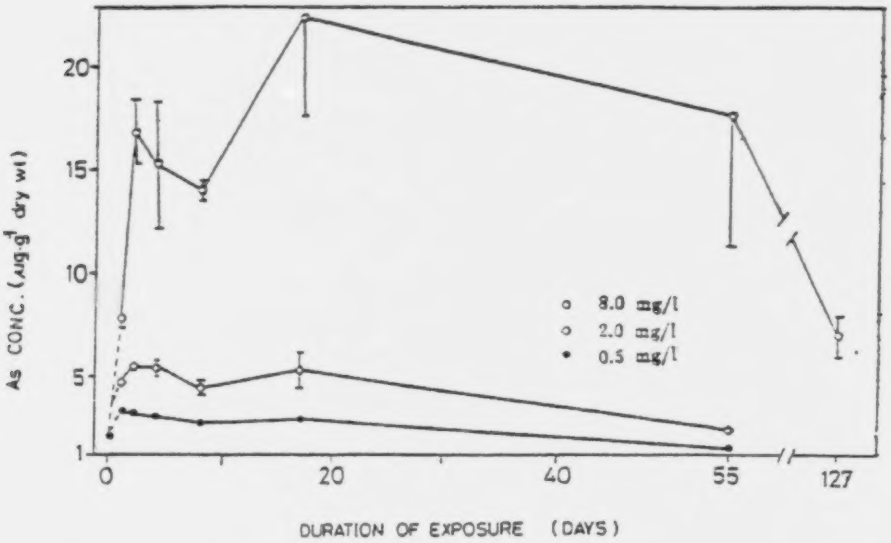


Figure 2. Whole body, total arsenic content of rainbow trout exposed to different levels of trivalent inorganic arsenic. L, I, H - Low, Intermediate and High concentrations, respectively.

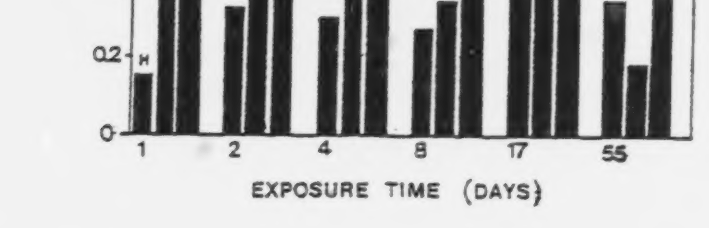


Figure 3. Bioconcentration factors of total arsenic content in rainbow trout exposed to different levels of trivalent inorganic arsenic. L, I, H - Low, Intermediate and High concentrations, respectively.

Paper: ACUTE AND CHRONIC TOXICITY OF WATERBORNE INORGANIC TRIVALENT ARSENIC TO RAINBOW TROUT (*Salmo gairdneri*)

Speaker: M. G. Rankin , University of Waterloo, Canada

P. Ross, University of Illinois, U.S.A.: Why are your experimental concentrations so much higher than OME guidelines? What would results be like at lower concentrations?

M. G. Rankin: As ^{3} is hard to dilute to low concentrations. Also, the OME guidelines were based on an application of 0.01, based on several species. At lower concentration, no toxicity would appear and BCFs would still be low.

Charles Bourque, Université de Moncton: Is there any evidence that the fish species is affecting the speciation of As^3 in the marine environment of the study.

M. G. Rankin: Did not look at the speciation of water at this time.

CHRONIC CONTAMINATION OF SAGUENAY FJORD BY MERCURY. E. Pelletier, C. Rouleau and G. Canuel. Institut National de la Recherche Scientifique INRS-Océanologie, 310, ave. Ursulines, Rimouski, Québec G5L 3A1

From 1947 to 1976, many tons of industrial mercury have been wasted into the Saguenay River and a large amount of that toxic heavy metal is now disseminated into the sediments of the Saguenay Fjord. Surface sediments (0-2 cm) have been collected at seventeen stations along the inner basin of the Saguenay Fjord and analysed for total mercury content. Also, about 150 shrimps (*Pandalus borealis*) fished in the Sainte-Rose-du-Nord area were used for mercury analyses and the determination of the mercury uptake rate from contaminated food. The mercury concentrations in surface sediments were ranging from 0.18 to 1.20 $\mu g.g^{-1}$ (dry weight) with a mean value of 0.63 $\mu g.g^{-1}$. This mean level is about one order of magnitude higher than the background level found in deep sediments. The examination of available data for surface sediments in the Sainte-Rose-du-Nord vicinity, located in the first half of the inner basin shows the "steady state" of the mercury contamination during the last 10 years (Figure 1). Indeed, the mercury concentrations observed in surface sediments were ranging from 0.75 to 1.20 $\mu g.g^{-1}$ with mean value of 0.93 $\mu g.g^{-1}$ since 1976. The steady state of mercury contamination can be explained only by two hypothesis: (1) an unidentified biogeochemical mechanism contributes to the mercury remobilisation from lower sediment layers (10-20 cm) and its vertical transportation up to the surface, or (2) the anthropogenic up-stream discharge of mercury was not really stopped in 1976 and one or many unidentified sources are still active along the Saguenay River. The mercury concentrations in the edible part of shrimps (fished in November 1985) were ranging from 0.13 to 0.58 $\mu g.g^{-1}$ (wet weight) with an average value of 0.36 ± 0.11 $\mu g.g^{-1}$. A positive and significant linear relationship (r=0.786) is observed between the Hg concentration in the edible part found in 1985 is not significantly different from the mean value reported in 1982. The mean concentration found in the exoskeleton and the head (pooled together) of shrimps was 0.26 ± 0.09 $\mu g.g^{-1}$. In order to estimate the mercury uptake rate by shrimps from contaminated food, a number of adult shrimps were fed with pre-contaminated mussel tissues (6.0 ± 1.0 $\mu g.g^{-1}$) for three weeks. A strong and fast increase of merury concentration was observed in the digestive organs after only 24 hours. The uptake rate in the edible part was estimated to 0.09 $\mu g.g^{-1}$ pr day during the first fourteen days of the bioassay. These findings clearly indicate the fragility of the equilibrium existing between the biota and the physical environment and how fast major changes can occur when food quality is modified.

Keywords: mercury, shrimps, sediment, Saguenay, bioassay, uptake rate.

Un rapport récent de Pêches et Océans (Rapp. Tech. Can. Hydrogr. Sci. Ocean. no. 32, 1984) indiquait qu'il y a une réduction très lente de la contamination de mercure chez les crevettes du Fjord de Saguenay dans les derniers dix ans, même si l'usine de chlore-alcali d'Arvida, la source de contamination de mercure, est fermée depuis 1976. Afin d'obtenir de nouvelles données sur la situation actuelle, des crevettes furent ramassées en automne 1985 à Sainte-Rose du Nord (environ 70 km en aval d'Arvida) et furent analysées pour leur teneur totale en mercure. Dans le muscle comestible, les concentrations de mercure variaient entre 0.13 à 0.58 $\mu g.g^{-1}$ et avaient une moyenne de 0.36 ug.g^{-1}. Les taux de mercure était en corrélation positive

(r=0.786) avec le poids humide des crevettes. Les concentrations de Hg trouvées dans l'exosquelette et les viscères (réunies ensemble) variaient de 0.26 à 0.09 μg.g^{-1} , mais aucun relation distincte peut être établie entre le taux d'Hg et l poids humide ou la longueur de crevettes. Une hypothèse sur le "niveau élevé naturel" de mercure contenu dans les crevettes du Fjord est discutée.

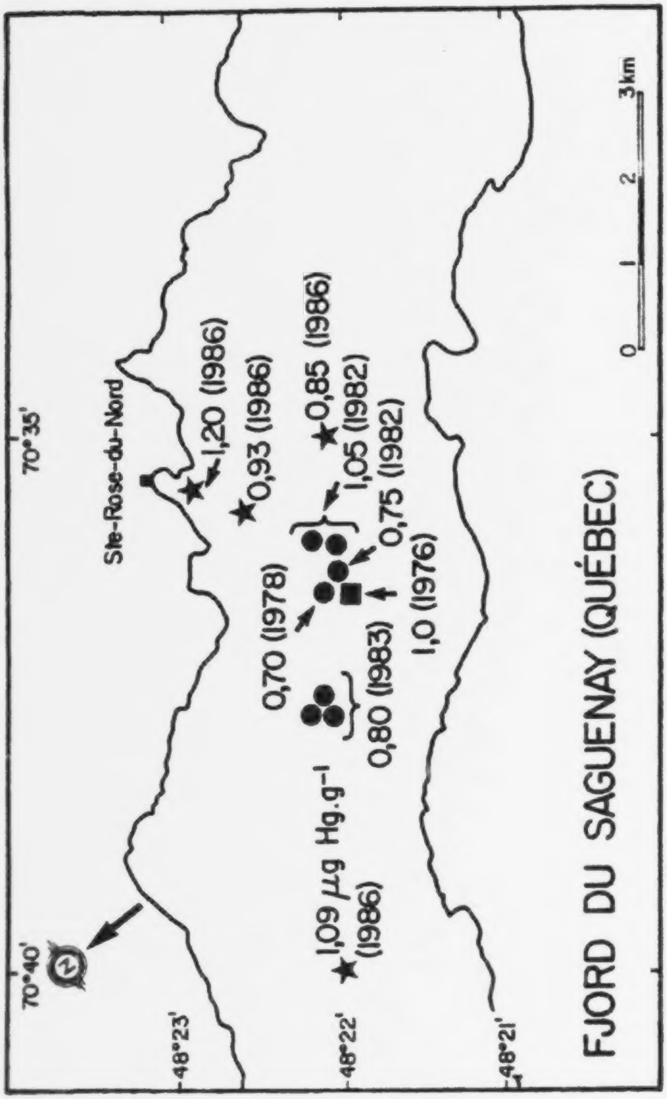


FIGURE 1: Distribution of mercury concentrations(μ g.g^{-1}, dry weight) observed in surface sediments (0-2 cm) since 1976 in the Sainte-Rose-du-Nord vicinity.

Paper: CHRONIC CONTAMINATION OF SAGUENAY FJORD.

Speaker: E. Pelletier , INRS-Océanologie, Rimouski, Canada

Peter Wells, Environment Canada, Halifax: Did you normalized your tissue levels of Hg found in the shrimp with the molting condition of the animals?

E. Pelletier: No, the fish has been catched in November so I think we are far from a molted period. I am not sure but I think we are quite far from molting spring mainly, we did not take this point into consideration.

Peter Wells: So you feel you were sampling a non-molt population at this time when you made your sampling?

E. Pelletier: We actually sampled shrimp late in fall to avoid that kind of problem.

ACCUMULATION AND DEGRADATION OF ALKYLLEAD COMPOUNDS BY A FRESHWATER ALGA. P.T.S. Wong, Y.K. Chau, J. Yaromich and O. Kramar, Department of Fisheries and Oceans, Great Lakes Fisheries Research Branch, Burlington, Ontario, Canada L7R 4A6

A common freshwater green alga, *Ankistrodesmus falcatus,* exposed to solution of trialkyllead, dialkyllead and inorganic lead compounds at 1 mg/L level for 24 h was found to accumulate these compounds with concentration factors of about 100, 2000 and 20,000 respectively. Incubation of the alga in trimethyllead and dimethyllead compounds over a long period of 28 d revealed the ability of the organism to metabolize these compounds. The metabolic processes for trimethyllead followed a sequential dealkylation process with the formation of dimethyllead and inorganic lead compounds. For dimethyllead, the alga was found to contain significant amounts of trimethyllead and inorganic lead compounds. The results suggest that algae could play an important role in the cycling of alkyllead compounds in the aquatic environment.

Keywords: alkyllead, accumulation, degradation, freshwater alga

On a trouvé que l'algue commune d'eau douce, *Ankistrodesmus falcatus*, exposée à des solutions de 1 mg/L de trialkylplomb, dialkylplomb et de plomb inorganique pendant 24 h accumulait ces composés à des facteurs de concentration d'environ 100, 2000 et 20,000 respectivement. L'incubation de cette algue pendant une longue période de 28 jours dans les composés de triméthylplomb et diméthylplomb, révèle la capacité de l'organisme à métaboliser ces composés. Les processus métaboliques suivent une séquence de désalkylation avec la formation de diméthylplomb et de composés de plomb inorganique.

Avec le diméthylplomb, l'algue contient des quantités significatives de triméthylplomb et de composés de plomb inorganique. Les résultats suggèrent que les algues pourraient jouer un rôle important dans le cycle des composés d'alkylplomb en milieu aquatique.

Mots clés: alkylplomb, accumulation, dégradation, algue d'eau douce

Paper: ACCUMULATION AND DEGRADATION OF ALKYL-LEAD COMPOUNDS BY A FRESHWATER ALGA

Speaker: J. Yaromich, Dept. of Fisheries and Oceans, Great Lakes Fisheries Research Branch, Burlington, Canada

Michael Waldichuk, West Vancouver Laboratory, Department of Fisheries and Oceans: Were you able to conduct degradation tests on the two alkyl-lead compounds at different pHs or in saline water?

J. Yaromich: No. The tests were all done at pH of 8 which was that of the medium used.

FACTORS AFFECTING THE MEASUREMENT OF TRACE METALS IN MARINE BIOLOGICAL TISSUE, C.L. Chou and J.F. Uthe, Fisheries and Environmental Sciences Division, Fisheries Research Branch, Department of Fisheries and Oceans, P.O. Box 550, Halifax, N.S., Canada B3J 2S7

Environmental studies employing biota as indicators of chemical contamination are comprised of a number of steps, i.e. sample collection, tissue sampling, chemical analysis, data handling, including statistics, and finally, interpretation. Problems within each of these steps have been identified in our studies on shellfish. These are; (1) sampling problems related to the non-random nature of animal capture, (2) animals affected by necrochemical changes after death, (3) autopsy and frozen storage of whole animals or tissue samples leading to changes in tissue trace metal concentrations and burdens, (4) the non-normal distributions in the data sets; transformation and various statistical techniques may be required for proper data handling.

Les études environnementales qui utilisent les organismes vivants comme indicateurs de la contamination chimique comprennent plusieurs étapes, i.e. collection des échantillons, échantillonnage des tissus, analyse chimique, traitement des données incluant les statistiques, et finalement l'interprétation. Les problèmes qui peuvent survenir lors de ces étapes ont été identifiés lors de nos études sur les crustacés. Ceux-ci sont: 1) problèmes d'échantillonnage reliés à la capture des animaux faite d'une façon non-alléatoire, 2) animaux qui sont affectés par des changements néchrochimiques après la mort, 3) autopsie et congélation des animaux ou des tissus qui peuvent amener des changements dans la quantité et la concentration des métaux traces dans les tissus, 4) les données qui ne suivent pas une distribution normale; des transformations et des techniques d'analyses statistiques variées qui peuvent être requises afin de traiter les données adéquatement.

THE ACUTE AND CHRONIC TOXICITY OF ANTIMONY TO *DAPHNIA MAGNA* AND RAINBOW TROUT:,

K. G. Doe, W. R. Parker, S. J. Ponsford and J. D. A. Vaughan, Environmental Protection Service, Conservation and Protection, Environment Canada, 45 Alderney Drive, Dartmouth, Nova Scotia B2Y 2N6

EXTENDED ABSTRACT

A New Brunswick mine discharge wastewater which typically contains about 7 mg/L of antimony. Past toxicity tests have shown this effluent to be non-acutely lethal to rainbow trout. Because of the paucity of published information on acute and chronic effects of antimony on fish and invertebrates, a project was started to investigate these effects using *Daphnia magna* and rainbow trout. Test material was antimony potassium tartrate.

Daphnia magna were less than 24 hours old and were tested at 20°C. Dilution water had a hardness of 250 ± 25 mg/L and a pH of 7.8 ± 0.2. Food was *Chlorella vulgaris* supplemented with a suspension of tetramin. Acute tests used 10 animals per 100 ml test solution and were of 2 days duration. Chronic tests used 1 animal per 50 ml and were renewed and fed three times per week. Survival and reproduction were measured to day 30, while survivors at day 33 were measured for length (growth effects). Antimony was measured by AAS and averaged 105.7% of nominal values. Results are expressed as nominal values of antimony.

Rainbow trout fingerling of mean weight 1.2 g were tested at 15°C. Dilution water had a hardness of 25 mg/L and a pH of 6.7-7.3. Ten fish were tested in 40 L of solution. Acute tests were of 4 days duration, while chronic tests lasted 30 days, with solutions renewed and animals fed every 3-4 days. Measured antimony values averaged 123% of nominal values and so results are expressed as geometric means of measured values. Trout were removed at the end of the exposures and measured for whole body levels of antimony.

The toxicity curve for antimony to *D. magna* is shown in Figure 1. The 2 day and 30 day LC50's, were 6.7 and 2.7 mg/L as antimony. Inhibition of reproduction is shown in Figure 2. The highest no observable effect concentration (NOEC) for impairment of reproduction was 1.7 mg/L. The highest NOEC for impairment of growth was 0.8 mg/L. In addition, acute tests were conducted on *D. magna* at measured water hardness of 31, 45, 92 and 220 mg/L. The corresponding 2 day LC50's were 5, 5, 5 and 6.7 mg/L as antimony.

The toxicity curve for antimony rainbow trout is shown in Figure 1. The 4 day and 30 day LC50's were 37 mg/L and 16 mg/L as antimony. Uptake of antimony into surviving trout after 30 days exposure is shown in Figure 3. Maximum bioconcentration factor was 3.4.

Water hardness had little effect on the acute lethality of antimony to *Daphnia magna* . These invertebrates proved to be more sensitive to antimony than rainbow trout. Of the three parameters monitored for chronic effects on *Daphnia* growth was the most sensitive. Reproduction was affected only at concentrations which caused high mortality. These chronic effects occurred at levels of antimony lower than that observed in the mine discharge. The maximum acceptable toxicant concentration (MATC) for antimony was estimated to be 1.2 mg/L.

Une mine du Nouveau-Brunswick décharge des eaux usées qui

contiennent typiquement environ 7 mg/L d'antimoine. Par le passé, des tests de toxicité ont démontrés que cet effluent n'était pas létale d'une façon aigue à la truite arc-en-ciel. En raison du très petit nombre de papiers publiés sur les effects aigues et chroniques de l'antimoine sur poissons et invertébrés, un projet visant à investiger ces effets utilisant *Daphnia magna* et truite arc-en-ciel fut mis sur pied. Le matériel testé était tartrate d'antimoine-potassium (antimony potassium tartrate).

Les *Daphnia magna* étaient agées de moins de 24 heures et furent testées à 20°C. L'eau de dilution avait une dureté de 250 ± 25 mg/L et un pH de 7.8 ± 0.2. La nourriture utilisée était *Chlorella vulgaris* complémentée avec de la tetramin. Les tests de toxicité aigue utilisèrent 10 animaux par 100 ml de solution et furent d'une durée de deux jours. Les tests de toxicité chronique utilisèrent 1 animal par 50 ml. Les animaux furent nourris et les solutions renouvellées 3 fois par semaine. Survie et reproduction furent mesurées jusqu'au jour 30 alors que les survivants au jour 33 furent mesurés pour leur longueur (effects sur la croissance). L'antimoine fut déterminé par spectroscopie AA et était en moyenne 105.7% des valers nominaux. Les résulats sont exprimés comme étant des valeurs nominaux d'antimoine.

Des truites arc-en-ciel juvéniles d'un poids moyen de 1.2 g furent testées à 15 C. L'eau de dilution avait une dureté de 25 mg/L et un pH de 6.7-7.3 10 poissons furent testés dans 40 litres de solution. Les tests de toxicité aigue étaient d'une durée de 4 jours alors que les tests de toxicité chronique furent de 30 jours, avec les solutions renouvellées et les poissons nourris tout les 3-4 jours. Les valeurs measurées d'antimoine étaient 123% des valeurs nominaux et par conséquent les résultats sont exprimés en moyennes géométrique de valeurs mesurées. Les truites furent enlevés à la fin des tests et analysées pour leur niveau corporel d'antimoine.

La courbe de toxicité de l'antimoine à la *D. magna* est montrée à la figure 1. Les 2-jour et 30-jour LC50 furent 6.7 et 2.7 mg/L d'antimoine. L'inhibition de la reproduction est montrée à la figure 2. La plus grande concentration avec aucun effet observable sur la détérioration de la reproduction était 1.7 mg/L. La plus grande concentration avec aucun effect observable sur la détérioration de la croissance était de 0.8 mg/L. De plus, des tests de toxicité aigue furent conduits sur *D. magna* avec des duretés mesurées de 31, 45, 92 et 220 mg/L. Les 2-jour LC50 correspondant furent 5, 5, 5, et 6.7 mg/L d'antimoine.

La courbe de toxicité de l'antimoine à la truite arc-en-ciel est montrée à la figure 1. Les 4-jour et 30-jour LC50 furent 37 mg/L et 16 mg/L d'antimoine. L'admission d'antimoine dans les truites ayant survécues 30 jours d'exposition est montrée à la figure 3. Le facteur maximum de bioconcentration était 3.4.

La dureté de l'eau avait peu d'effet sur la létalité aigue de l'antimoine sur *Daphnia magna* . Ces invertébrés se sont démontrés comme étant plus sensible à l'antimoine que les truites arc-en-ciel. Des trois paramètres à l'étude en ce qui concerne les effets chroniques sur *Daphnia* , la croissance était la plus affectée. La reproduction fut affectée seulement à des concentrations causant un haut taux de mortalité. Ces effets chroniques ont apparus à des niveaux d'antimoine inférieur à ceux observés dans la décharge de la mine. La concentration d'agent toxique maximum acceptable pour l'antimoine fut estimée à 1.2 mg/L.

Figure 1 LETHALITY OF ANTIMONY

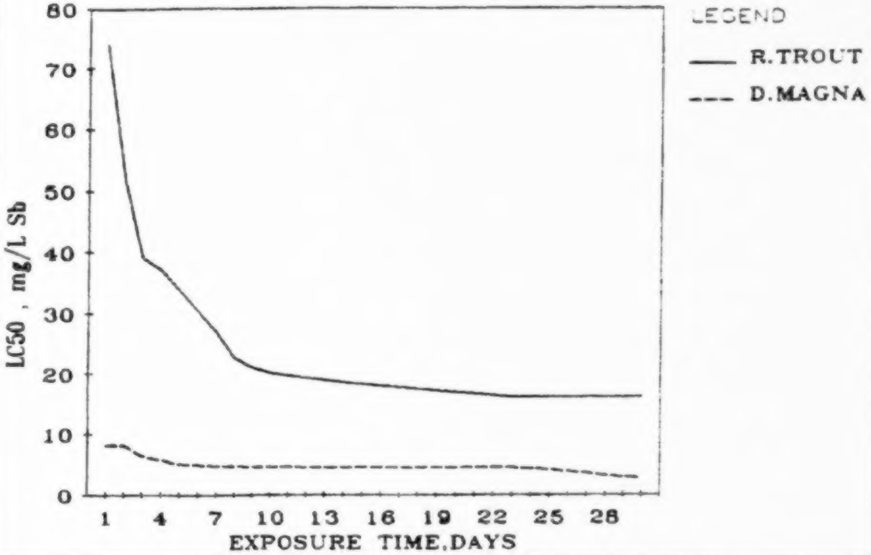


Figure 2 UPTAKE OF ANTIMONY IN RAINBOW TROUT TISSUE

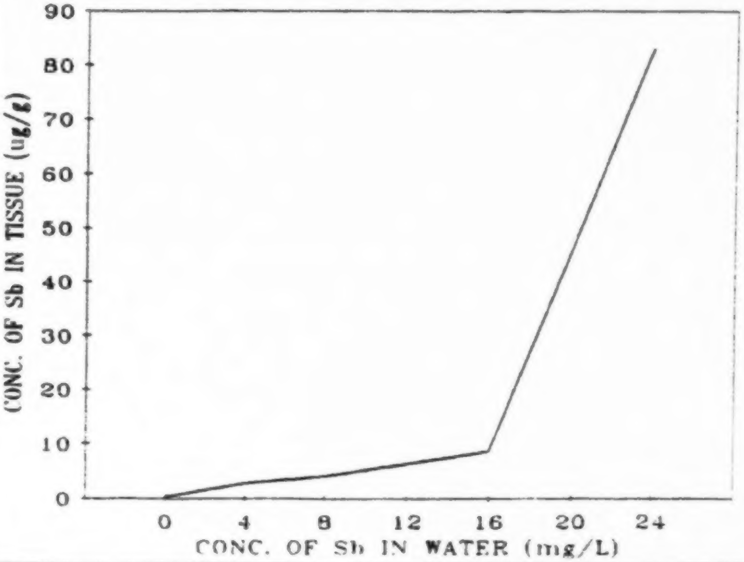
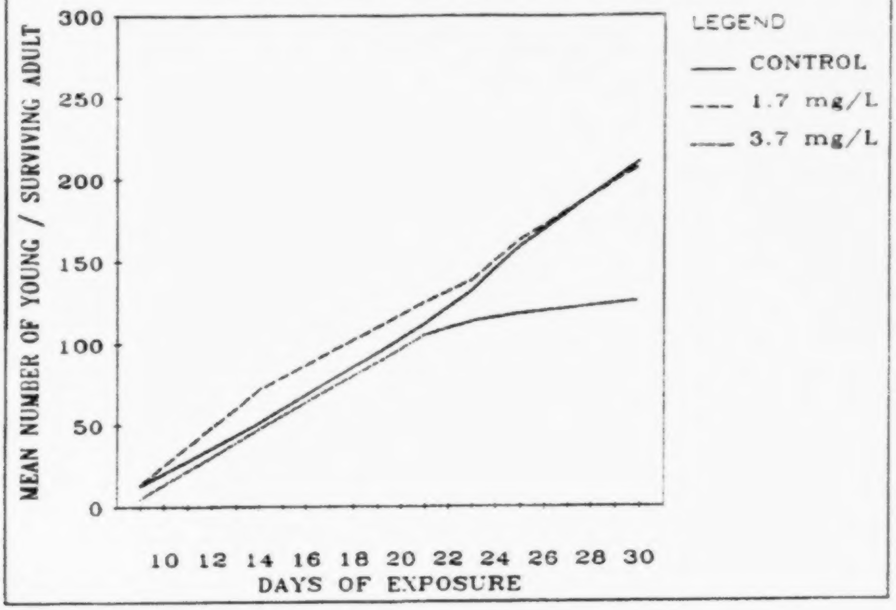


Figure 3 DAPHNIA REPRODUCTION



ASSESSMENT OF REPRODUCTIVE CAPACITY AND LARVAL DEVELOPMENT OF FERAL WHITE SUCKERS (*CATOSTOMUS COMMERSONI*) EXPOSED TO CHRONIC ELEVATIONS OF COPPER AND ZINC,

K. R. Munkittrick and D. G. Dixon, Biology Dept., University of Waterloo, Waterloo, Ontario N2L 3G1

EXTENDED ABSTRACT

This project was undertaken as an integrated field-laboratory program designed to determine the impacts of copper and zinc contamination on white sucker (*Catostomus commersoni*) populations of several lakes in the Manitouwadge district of Ontario. Lakes were evaluated on the basis of accessibility, preliminary sample collections and historical metal status. Mean assayed copper concentrations (ug/l,std.dev.,n.) were 15.3 for Manitouwadge Lake (MAN:4.2,35), 13.3 for Little Manitouwadge Lake (LMN:3.7,21) less than 2.0 ug/l for Loken Lake (LOK:control site). Mean zinc concentrations (ug/l,std.dev.,n) were 253 for MAN (62.4,35), 209 for LMN (20.3,21) and 26.1 for LOK (22.4,11).

Age, weight and length data for the metal contaminated sites were combined since there was no difference in the relationship of age with either weight (p=.156) or length (p=.479). At age 4 there were no significant differences in either length or weight between the control and metal sites, but control females were longer and heavier than metal fish at ages 6, 7, 8 and 9. Results were similar for males. At LOK, 40.6% (13/32) of the 4 and 5 year old female fish captured were immature. It appears that after attaining maturity, the metal contaminated fish are unable to meet the energetic requirements of both reproduction and growth. The increased impact on females supports this hypothesis since females require more energy for reproduction than males. The age of the fish which failed to spawn ($n=6,\bar{x}=5.5$) suggests that these fish may have been attempting to spawn for the first time. Although the significance of this finding is not clear at this time, we cannot attribute the results solely to the impact of metal contamination, since two fish from the control site also failed to spawn.

Control fish had significantly higher fecundity (31200, 2619,19) than either MAN (22635,746,26) or LMN fish (21863,958,22) ($p<.0001$) at similar ages (LOK 7.0,2.0,20, MAN 6.9,1.8,26, LMN 7.3,1.0,24). Although, the fecundity of all fish showed highly significant positive relationships with length and weight, only LOK fish showed a positive relationship with age. Fecundity at both metal contaminated sites showed no relationship with age and is a reflection of the failure of these fish to show increases in weight or length after attaining sexual maturity.

At spawning time, eggs were collected from individual females at each collection site, fertilized in duplicate with a pool of milt, water hardened and incubated in clean water before transportaton to the University of Waterloo. There was no significant difference in fertilization rate between the metal contaminated site (79.7,5.5,20) and the control site (82.2,1.7,20) (p=.590). The fertilization rates of eggs collected from 10 redds at MAN were 78.3% (7.6) while the fertilization rate of the pooled LOK sample was 78.0%. There was no impairment of the fertilization process in gametes collected from the metal contaminated sites.

MAN larvae were significantly shorter (10.48 mm, 0.10,30; p=.008) and lighter (6.6 mg, 0.2,30; p=.011) than the LOK larvae (10.85 mm, 0.12,30; 7.3 mg,0.3,30) at 2 d post-hatch. The rate

of deformation was 3.78% for MAN and 2.50% for LOK. Eggs collected from the redds and hatched in the lab yielded a deformation rate of 6.0%. In addition to the slight increase in developmental rate, unfed MAN larvae died at faster rate than LOK larvae. All MAN unfed larvae were dead by 29 d ph (post-hatch), while some LOK larvae continued to live until 42 d. Furthermore, an increase in the survival rate of MAN fed larvae over unfed could be detected by 25 d ph, while a similar point for LOK was 34 d ph.

Beginning at 1 d post-hatch (ph), larvae were exposed to waterborne copper in 144 hr continuous flow bioassays. New tests were started every 4 d until 37 d ph. Preliminary bioassays found the 96 h LC50 to be around 350 ppb copper, and the survival times at 900 ppb to be less than 48 hrs. Lethal toxicity did not occur at these concentrations until 9 d ph, and it was necessary to add two additional concentrations (1200,2200 ppb) at this time. Although it was not possible to calculate an accurate LC50 for MAN larvae at his age, LOK larvae showed higher mortality at 2200, 1200 and 900 ppb (nominal:144hr LC50 1275 (1158-1402); 96 hr 886 (802-978). Furthermore, the resistance times of MAN larvae to 2200 ppb copper was twice as long as LOK larvae. This suggests that the tolerance and resistance of MAN fish to copper was increased by a factor of at least 2 at this age.

Assays started at 29 d ph showed the resistance of fed fish to be higher than unfed at both sites. This was the last day any MAN unfed larvae remained alive. Furthermore, all assays of MAN larvae started after the completion of yolk absorption (18-20 d) showed decreased resistance when compared with larvae tested before this time period. If the increased tolerance and resistance of the MAN fish was the result of genetic adaptation, we would expect the increased survival to be evident at all ages tested. Bioassays conducted at 33 d, 37 d and 4 months of age do not show this to be the case. Furthermore, the LT50 at 2200 ppb copper for cross-fertilized larvae at 9 d ph (18.5hrs, 17.2-19.5) was not significantly different from 9 d ph LOK unfed larvae (19.4 hrs, 17.6-21.4) and neither was the mortality rate at 900 ppb (3/10 at 9 d ph). In both cases these resistance times are signifiantly lower from the larvae from contaminated eggs and milt (9d fed 44.8 hrs, 42.0-48.0, 9 d unfed 38.4, 36.0-41.0). In fact, the only time periods tested which suggest increases in tolerance and resistance are those conducted during the period of endogenous (yolk) nutrition, suggesting the presence of factors in the yolk which infer an advantage to survival. These factors appear to be maternal in origin and future trials will attempt to identify them.

Acknowledgements

This project was funded through the Ontario Ministry of the Environment (Project 193 R). Our appreciation is extended to Dr. C. Neville for her assistance during the course of this research. Additional financial assistance was received from the Natural Sciences and Engineering Research Council.

Keywords: copper, zinc, suckers, reproduction, fertilization, larval development.

Des populations de Castostome noir furent examinées afin de déterminer si la diminution dans la reproduction était associée avec une exposition chronique à des niveaux élevés de cuivre (11-13 ug/l) et de zinc (220-236 ug/l). Les poissons des sites contaminés démontrèrent une diminution de poids, de longueur, et

de croissance relativement à des sites contrôles. Ils démontrèrent également une augmentation dans l'index hépatosomatique et une diminution du succès de frayage. Aucun effet sur le taux de fertilisation et d'éclosion ne fut observé, mais les poissons de ces sites contaminés démontraient une production d'oeufs de taille plus petites, des augmentations dans la fécondité relative et dans le volume de laitance. De plus, les larves ds sites contaminés démontraient des diminutions significativs dans la longueur et le poids relativement aux contrôles, ainsi qu'un taux de développement plus grand, une moins bonne conversion à la nutrition exogène et une diminution marquée dans le temps de survie en l'absence de nourriture. La pertinence des résultats obtenus en laboratoire en fonction des observations sur le terrain sera discutée.

A RAPID ANALYTICAL PROCEDURE FOR CYANIDE DETERMINATION IN AQUEOUS SAMPLES, M.C. Mehra and A. Arseneau, Département de chimie et biochimie, Université de Moncton, Moncton, N.-B. E1A 3E9

The use of cyanide in extractive metallurgy (Au and Ag) and the synthesis of organic reagents often leads to the contamination of the aqueous industrial effluents. Since this is toxic and potentially dangerous to human health and aquatic life, constant monitoring of the cyanide bearing effluents is deemed necessary by the regulatory agencies. The popular analytical methods for CN- analysis encompass UV/Visible spectrophotometry, atomic absorption or gas chromatography. The first named technique is still popular for reasons of simplicity and rapidity. However, prior CN- separation is always resorted to in order to eliminate the interference of the coexisting species. The present communication shall describe a distillation procedure for CN- separation and eventual quantification in ppm range through the use of a new chromogenic reagent ferene. The principle of the analytical procedure is based on the ligand exchange reaction at a controlled pH between mercuric ferrenate and the cyanide distillate. The linear analytical response occurs in 0.03 - 2.0 ppm range. The usefulness of the method has been demonstrated in the analyses of samples of varying matrixes.

L'utilisation du cyanure dans la métallurgie extractive (Au et Ag) et la synthèse de réactifs organiques mènent souvent à la contamination des effluents aqueux industriels. Vu que ceci est toxique et potentiellement dangereux à la santé humaine et la vie aquatique, une surveillance constante des effluents contenant du cyanure par les agences régulatoires est nécessaire. Les méthodes analytiques populaires pour l'analyse du CN^- utilisent la spectrophotométrie UV/visible, l'absorption atomique ou la chromatographie à phase gazeuse. La première technique nommée est encore populaire car elle est simple et rapide. Par contre, la séparation préliminaire du CN^- est toujours utilisée afin d'éliminer l'interférence d'espèces coexistentes. La présente communication décrit une technique de distillation pour effectuer ls séparation du CN^- et éventuellement la quantification en ppm en utilisant un nouveau réactif chromogénique férène. Le principe de la procédure analytique est basé sur la réaction d'échange de ligand a un pH controlé entre le ferrenate mercureux et les distillats de cyanure. La réponse linéaire analytique se produit dans l'écart de 0,03-2.0 ppm. L'utilité de cette méthode a été démontrée dans l'analyse d'échantillons de matrices variées.

Paper: A RAPID ANALYTICAL PROCEDURE FOR CYANIDE DETERMINATION IN AQUEOUS SAMPLES

Speaker: M. C. Mehra , Université de Moncton, Moncton, Canada

Suzanne Roussel, EPS, Environment Canada: How would you identify each metallic complex in a sample of total metallic cyanide complex.

M. C. Mehra: In fact we do not identify metallic complexes. It is difficult to analyse. If we start with a preformed metal cyanide you can break it up and get 100% recovery.

Suzanne Roussel: With your method can you analyse for individual cyanide metallic complexes?

M. C. Mehra: I do not think so. You can not analyse various metal cyanides but you can analyse cyanide in the presence of various metals.

R. Van Coillie: The most harmful form of cyanide is HCN for the toxicity. There is speciation of cyanide inside the sediment and inside the water. Can you distinguish with your method 2 to 3 different speciations of cyanide?

M. C. Mehra: We did not study speciation. We analysed uniquely CN negative which we thought to be the first form that enters the ecosystem in a dissolved state in water.

PARASITE LOAD AND HEMATOLOGICAL PARAMETERS IN WILD FISH SPECIES WITH ELEVATED RADIONUCLIDE LEVELS. J. W. Bernstein, Department Applied Microbiology and Food Science, University of Saskatchewan, Saskatoon, Saskatchewan S7N 0W0 and S. M. Swanson, Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, Saskatchewan S7N 2X8

Studies of accumulation of uranium (U) series radionuclides in aquatic systems have shown elevated levels in plants and animals near mines or high natural background areas. Investigations of the effects on aquatic animals in these systems have predominately focussed on population dynamics such as growth and fecundity. In Saskatchewan, Canada, considerable deposits of high grade uranium ore have been found. From 1952 to 1982 a uranium mine and mill located in northern Saskatchewan near Uranium City, was operated by Eldorado Nuclear Ltd. The mill tailings were discharged into a natural drainage system which ultimately drains into Beaverlodge Lake. This study investigated parasite load and hematological parameters in three wild fish populations in Beaverlodge Lake and two nearby control lakes. The control lakes, Milliken and Fredette, do not receive run-off from any operating or abandoned mines, although they are part of the same drainage basin.

Three fish species from Beaverlodge Lake, white suckers (*Catostomus commersoni*), lake whitefish (*Coregonus clupeaformis*) and lake trout (*Salvelinus namaycush*), were found to have significantly elevated U-series radionuclide levels ($p<0.001$) (e.g. U238, radium-226 and lead-210). Both Ra-226 and Pb-210 are primarily deposited in the skeleton and these may pose a danger by emitting alpha and beta particles into surrounding tissue. This study investigated the general health of the Beaverlodge Lake and two control fish populations. The objectives were to (1) document tumors, lesions and other abnormalities and inventory parasite levels and (2) evaluate standard blood parameters based on the known relationship between lead, radiation and the hemopoietic system.

Gross necropsies revealed no evidence of tumors, lesions or abnormalities. Histological results revealed lesions primarily associated with parasite infestation. There were however differences in number and types of parasites observed. Lake whitefish exhibited higher levels and a greater variety of parasite types than did common suckers. Parasite number and level in the contaminated Beaverlodge Lake common sucker population were significantly lower than that seen in the control lake. It was hypothesized that this may be due to radionuclide levels affecting benthic faunal diversity and thus intermediate host populations. These potential effects are being investigated further.

The blood parameters, packed cell volume, total protein and erythrocyte counts, were significantly lower in common suckers and lake whitefish from Beaverlodge Lake in comparison to the control lakes. White blood cell counts in Beaverlodge suckers and whitefish however, were significantly higher than those in control lakes. These higher white cell counts were due to greater numbers of neutrophils in the suckers and to greater numbers of lymphocytes in the whitefish.

Lake trout blood results either showed no significant differences or the differences that did occur were in the reverse direction. Common suckers and lake whitefish had greater radionuclide burdens in contrast to lake trout which sometimes exhibited levels similar to control fish. Thus blood parameter differences might be expected to be less pronounced since radionuclide levels are lower in this species.

In field studies of this type, unknown factors can contribute and it is often unclear to what degree they may influence the results. The fact that consistent differences were found in blood parameters in species with the highest radionuclide levels and that little is known concerning alpha and beta radiation in comparison to gamma, indicates that laboratory studies are needed to further investigate and verify the effects of this type of radiation in fish.

Ce travail fut réalisé afin d'étudier les parasites et les paramètres hématalogiques chez trois populations naturelles de poissons dans le nord de la Saskatchewan; une en provenance d'un lac avec un taux de radionuclides élevé et les deux autres provenant de lacs témoins. Les poissons du lac contaminé avaient des taux de radionuclides élevés, étaient plus petits, présentaient un taux de croissance et une fécondité moindre que les populations témoins. Une autopsie et des examens histologiques furent effectués. Des échantillons de sang prélevés sur le terrian furent utilisés pour déterminer le PCV, le nombre de globules blancs et rouges et le taux de protéines totales. Les décomptes différentiels de globules blancs furent réalisés en laboratoire. Les poissons en povenance du lac contaminé avaient un nombre de parasite moindre, un taux de PCV, de PT et de CBR significativement plus faible. Il avaient cependant un décompte différentiel de globules blancs significativement plus élevé. Ce décompte différentiel était aussi différent significativement chez les 3 populations.

Paper: HEMATOLOGICAL PARAMETERS AND PARASITE LOAD IN WILD FISH WITH ELEVATED RADIONUCLIDE LEVELS

Speaker: J. W. Bernstein , Saskatchewan Research Council,
Saskatoon, Canada

K. Munkittrick, University of Waterloo: Which species of parasite was the most prevalent in the white suckers?

J. W. Bernstein: An intestinal acanthocephalan.

K. Munkittrick: Our studies on mining wastes and white suckers we found the same parasite to be most prevalent. Furthermore, as in your study, both the prevalence and intensity was higher in the control lake than the contaminated lakes.

R. Van Coillie: Could you tell me whether the high level radionuclide levels can affect the synthesis of anti-corps in fishes?

J. W. Bernstein: Some Russian work relating this aspect stated that there was such a relation. If there is such a relation, I do not know exactly how it is produced.

NAFION - AN ION EXCHANGE MEMBRANE SUITABLE FOR SPECIATION STUDIES,

C.L. Bourque and R.D. Guy, Département de chimie et biochimie, Université de Moncton, Moncton, N.-B. E1A 3E9

NAFION 811X, a perfluorosulfonic acid cation exchange tubular membrane, was used in the sodium form to differentiate between free and bound metal species. Permselectivity of the membrane results from two mechanisms - charge and size exclusion. Under experimental conditions, "free" hydrated metal ions dialyzed and reached equilibrium after 120 minutes where as anionic species (e.g. Cd-NTA$^-$) were completely charge excluded. Large cationic species (e.g.ϕ_3Sn^+) were also completely excluded, presumably a size exclusion mechanism. A neutral species (2-methyl-5-nitroimidazole) dialyzed slowly and was 26% dialyzed after 120 minutes. In order to minimize Donnan preconcentration and adsorption of metal ions onto the membrane, an ionic strength adjuster (0.30M $NaNO_3$) was required. The speciation method was used to compare dialyzate concentration ("free") with calculated speciation using well-established stability constant data. Good agreement was generally attained. Metal binding with humic and fulvic acids was also investigated. The method is suitable where complexation is the principal binding mechanism but is not applicable where ion exchange plays an important role.

Keywords: speciation, dialysis, Nafion, ion exchange, metal ions

Le Nafion 811X, une membrane polymère perfluorosulfonatée, échangeuse de cations et de géométrie tubulaire, fut utilisée pour différencier la fraction libre de la fraction liée. La perméabilité de cette membrane est supposée dépendre de deux paramètres - une sélectivité à base de la charge et des dimensions de l'espèce. Dans nos conditions expérimentales, l'ion hydraté diffusait à travers la membrane, atteignant l'équilibre après 120 minutes. Cependant, les complexes anioiques (i.e. Cd-NTA$^-$) et les complexes cationiques volumineux (i.e. ϕ_3 Sn$^+$) étaient complètement exclus, probablement le résultat de leurs charges et de leurs dimensions, respectivement. Une espèce neutre (le 2-méthyle-5-nitroimidazole) atteignait seulement 26% de sa valeur maximale après 120 minutes. Un ajusteur de force ionique était nécessaire dans cette technique afin de minimiser une préconcentration due à l'équilibre Donnan et afin de minimiser l'absorption de l'analyte sur la membrane par un mécanisme d'échange d'ions. La méthode fut caractérisée en comparant les résultats de la dialyse avec ceux de la spéciation calculée. En général, cette corrélation était bonne. La méthode fut également utilisée pour étudier les intéractions entre métaux et les acides humiques et fulviques. La méthode est applicable là où la complexation demeure le mécanisme principal d'absorption.

Paper: NAFION - AN ION EXCHANGE MEMBRANE SUITABLE FOR SPECIATION STUDIES

Speaker: C. L. Bourque: Dept. de chimie et biochimie, Université de Moncton, Moncton, Canada

Don McGregor, Environnement Canada, Ottawa: Je me demande ce qu'est le but de ces études, est-ce que ce n'est pas pour étudier cette question dans des échantillons plutôt provenant véritablement d'une rivière et d'un lac. Mais si vous avez un système où il y a plusieurs ions en équilibre, comment ajustez-vous votre méthode qui est véritablement dynamique et qui va donc changer l'équilibre? Vous supposez que vous le faites. Comment pouvez-vous être certain que cela ne va pas détruire l'équilibre?

C. L. Bourque: Il faut faire attention lorsque vous préparez l'électrolyse. Premièrement une des choses que vous devriez remarquer c'est que dans la plupart de ces techniques il y a un changement dans l'équilibre, mais la plupart des traites sont plus rapides que cela. Oui, toutefois, elles ont des limites,mais certaines par exemple ont des problèmes d'absorption. Un autre exemple pour le même technique c'est que la fraction que vous mesuriez peut provenir de la dissociation qui arrive sur la surface même de l'électrolyse. Je ne propose pas que notre technique nous avions est la meilleure c'est un domaine très frustrant car chacune des techniques à des limites. Mais je pense que cette technique est très utile lorsque vous l'utilisez pour des études de modèle ou d'échantillon d'eau de mer. Si vous avez des telles échantillons, voulez-vous vérifier que la force ionique des deux côtés de la membrane est très semblable ou même identique.

R. Van Coillie, Env. Canada, Montreal: Est-ce que vous vérifier la toxicité de chacune des portions de spécialisation?

C. L. Bourque: Vous voulez dire correlation.

R. Van Coillie: Si vous voulez vérifier si deux ou trois, s'ils sont différent du cadmium. Est-ce que vous avez vérifier une qui est plus toxique qu'une autre?

C. L. Bourque: Eh bien, ce travail a été conçu pour obtenir une nouvelle technique de speciation. Elle doit être utilisée corrélation avec d'autre technique de speciation ou avec une donnée toxicité et cela n'a pas encore fait.

Session 3. BIOLOGICAL AVAILABILITY AND EFFECTS OF PARTICLE BOUND CONTAMINANTS.

DISPONIBILITE ET EFFETS BIOLOGIQUES DES CONTAMINANTS LIES A DES PARTICULES.

MORRY, C., Chairman

COMPARISON OF SEDIMENT TOXICANT EXTRACTION PROCEDURES FOR MICROTOX TOXICITY SCREENING TESTS:

K. K. Kwan and B. J. Dutka, Canada Centre for Inland Waters, Burlington, Ontario L7R 4A6

This study evaluates two types of solvents to extract toxicants from sediment samples collected from Lake Saint Louis, Quebec. The sediment samples were extracted using Milli-Q reagent grade water prepared from distilled water and lake water, collected 1 meter above the sediments. The extracts were tested for toxicity levels using the Microtox toxicity screening test. Results indicate that the toxic level of extracts using Milli-Q reagent grade water were 14.3 to 100 percent higher than those using lake water.

Cette étude évalue deux types de solvants utilisés pour extraire des produits toxiques d'échantillons de sédiments provenant du Lac Saint-Louis, Québec. L'extraction se fait grâce à de l'eau de type Milli-Q réactif préparée à partir d'eau distillée et l'eau de lac pris à 1 m au-dessus des sédiments. Les extraits furent analysés pour niveau de toxicité grâce au test Microtox. Les résultats indiquent que le niveau de toxicité des extraits étaient de 14.3% plus élevé pour les échantillons utilisant l'eau de type Milli-Q réactif que pour ceux utilisant l'eau de lac.

INTRODUCTION

Chemical analysis of sediments even though providing useful information on the toxicant composition of sediments, does not provide information on the degree of toxicity. The toxicity effect of a sediment can only be measured by biological means. Many of the preferred biological tests being used are based on microbial or microbial enzyme activity (Liu and Dutka, 1984). Therefore, the use of solvents other than water may influence the outcome of a microbiological toxicity screening test. This study was initiated to evaluate Milli-Q reagent grade water (low response water) and lake water (1M from bottom) as potential solvents to extract sediment samples collected from Lake Saint Louis.

METHOD

Samples

Eighteen sediment samples were collected by Ekman dredge from Lake Saint Louis (Figure 1) for comparison of the toxicity levels of the sediment extracts using the Microtox toxicity screening procedure. Upon collection, the surface water was drained off and the top 10 cm of each sediment sample was collected with a sterile spatula and placed into a sterile 500 mL polypropylene bottle which had been acid washed. The bottled sediment samples were then placed in melting ice. All samples were processed within 24 hours of collection.

Toxicity Screening

From each sample, 50 grams of sediment were weighed and placed into an acid washed and Milli-Q reagent grade water rinsed (5 times) BOD bottles. Fifty mL of Milli-Q reagent grade water were added to the bottle of sediment. Similarly, 50 grams of sediment were also weighed and placed into a second BOD bottle and 50 mL of lake water were added. The lake water was collected from Lake Saint Louis 1 metre above the sediment. The bottles were stoppered and shaken vigorously by hand for two minutes. The mixtures were then decanted into 250 mL Nalgene centrifuge tubes and centrifuged for 20 minutes at 10,000 rpm at 4 C. The extracts were then used to test for toxicity levels via the Microtox toxicity screening procedure.

The Microtox toxicity screening procedure was carried out following the procedure detailed in the 1982 Beckman Instruments Inc. Manual, with contact time of 15 minutes (Dutka and Kwan, 1982). Data are reported in the number of grams that are required to produce an EC50. EC50 is defined as the concentration of test sample that caused a 50 percent decrease in light output during the Microtox toxicity screening procedure.

RESULTS AND DISCUSSION

Table 1 presents the EC50 values obtained from the sediment samples collected from Lake Saint Louis. EC30 values are presented when EC50 values were not able to be calculated from dose-response curves. From the data it can be seen that sediments extracted with Milli-Q reagent grade water yielded higher toxicity values than those extracted with lake water. The toxicity levels for sediments extracted with Milli-Q reagent grade water were 14.3 (sample F(b)) to 100 (samples A&O) percent higher than those sediments extracted with lake water.

Table 2 presents the pH values of the sediment and lake water samples. The average pH of five measurements of Milli-Q reagent grade water was 6.6. From Table 2, it can be seen that the pH values of the lake water samples are 1.3 to 1.8 units higher than the Milli-Q reagent grade water. However, the alkaline nature of the water samples were similar to the sediment samples. It appears that when solvent (lake water) and solute (sediment sample) have the same alkaline characteristic, lower toxicity levels are produced consistently thean when a solvent (Milli-Q reagent grade water) with acidic characteristics is used as seen from Table 1. These data confirm reports by Hem (1970) theat the toxicity levels of the sediment extracts depends on the pH of the sediment and the solvent used.

The study results indicate that: 1. the degree of toxicity as measured by toxicant screening tests is very much dependent on the difference in pH between the solvent and the solute, 2, there is a great need for standardization of solvents used in sediments extraction for microbial toxicity screening tests.

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Liu, D. and B. J. Dutka. 1984. Toxicity Screening Procedures using Bacterial Systems. Marcel Dekker, Inc., New York and Basel.

Sample No.	EC 50	
	Milli-Q Water gm	Lake Water gm
A	0.43	N.D.**
B	0.08	0.15
C	0.02	0.06
D	0.08	0.22
E	0.05	0.09
F (a)	0.04	0.10
(b)	0.18	0.21
G	0.16	0.22
H	0.03	0.06
I	0.07	0.10
J	0.04	0.08
K	0.05	0.13
L (a)	0.05	0.13
(b)	* 0.10	* 0.25
M (a)	0.09	0.14
(b)	* 0.10	* 0.17
N	0.10	0.19
O	0.21	N.D.

* EC30 values
**Not Detected

TABLE 1. Microtox EC50 values of sediment samples extracted with Milli-Q reagent grade water and lake water.

Sample No.	pH Values	
	Sediment	Lake Water
A	7.5	8.2
B	7.6	8.0
C	7.3	8.1
D	7.3	8.3
E	7.4	8.3
F (a)	7.3	8.3
(b)	7.2	8.3
G	7.4	8.2
H	7.5	7.9
I	7.6	8.1
J	7.9	8.2
K	7.3	8.1
L (a)	7.5	8.3
(b)	7.6	8.3
M (a)	7.4	8.2
(b)	7.3	8.2
N	7.6	8.4
O	7.4	8.3

TABLE 2. pH values of sediment and lake water samples.

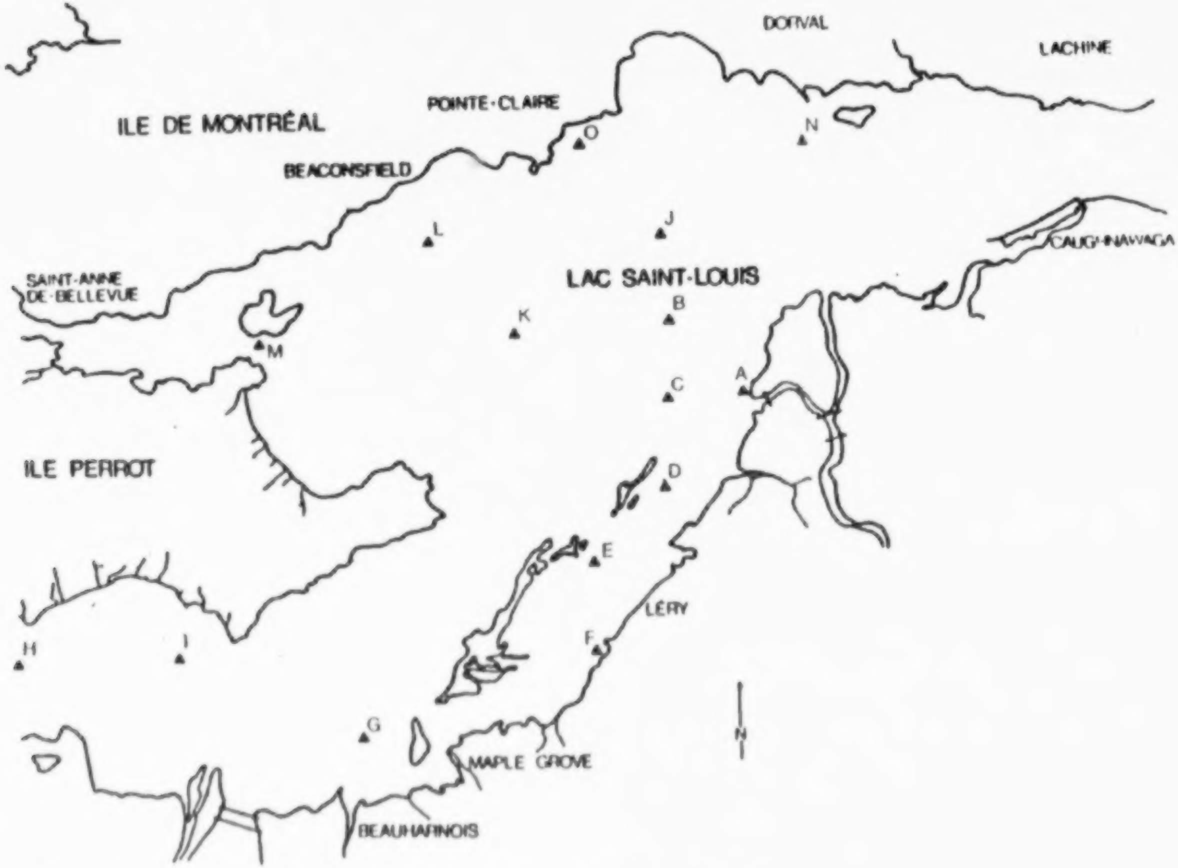


Figure 1 LOCATION OF SAMPLING SITES - LAKE ST. LOUIS

Paper: PRIORITY SITE SELECTION FOR DEGRADED AREAS BASED ON MICROBIAL AND TOXICANT SCREENING TESTS. 1. LAKE ONTARIO, CANADIAN INSHORE AREAS

Speaker: K. K. Kwan, National Water Research Institute, Burlington, Ontario

Christian Blaise, Environment Canada, SPE, Longueuil, Quebec: How was the genotoxicity repeated for the 505 Chromotest? Positive/negative or induction potential?

K. K. Kwan: Not known as work on 505 Chromostat was not performed by the speaker.

ROLE OF DISSOLVED OXYGEN IN THE DESORPTION OF MERCURY FROM FRESHWATER SEDIMENT.

J. S. Wang, P. M. Huang, U. T. Hammer, and W. K. Liaw, Department of Soil Science, University of Saskatchewan, Saskatoon, Canada S7N 0W0

The impact of the oxygen depletion, which was induced by eutrophication, on the Hg dispersion from bottom sediment of stratified lakes has not been well understood. This study investigated the influence of the dissolved oxygen on the kinetics of the release of Hg from the sediment of a freshwater lake (Katepwa Lake) in Saskatchewan, Canada. The desorption process obeyed the multiple first order reaction; a fast desorption occurred within one hour which was followed by a low desorption process. When the dissolved oxygen level decreased from 4.0 to 0.0 μg/ml (the Eh decreased from 450 mv to -35 mv), the rate of desorption was increased by 1.2 to 1.9 times for the fast desorption and by 15 to 24 times for the slow desorption process. This indicates that more Hg was released from the oxygen depleted sediment and the influence of the dissolved oxygen levels on the rate of the Hg release became greater as the reaction proceeded. Temperature had little effect on the Hg release under the level of the depleted dissolved oxygen and the temperature range studied.

Substantial amounts of Fe and Mn were dissolved in the solution of the N_2-H_2 treated samples upon the depletion of oxygen. In contrast, the dissolution of Fe and Mn from the untreated samples was not detectable. The increase in the Hg release in the oxygen depleted samples can be partially attributed to the dissolution of Fe and Mn oxides. Since hydrous Fe an Mn oxides have high capacities to adsorb Hg, the adsorbed Hg may be released to the solution when the Fe and Mn oxides become unstable and partially dissolved upon the depletion of oxygen in the system. Because Hg was adsorbed on the surface of the hydrous Fe and Mn oxides, the dissolution of the oxides would result in the concomitant release of Hg. Th data indicate that the dissolution of the Fe and Mn oxides is a significant mechanism involved in releasing Hg from the sediment to pore waste when the dissolved oxygen is sufficiently depleted.

L'impact de la perte d'oxygène, causée par l'eutrophication, dans les sédiments des lacs, sur la dispersion du Hg n'est pas bien comprise. Donc, le but de ce travail était d'étudier l'influence de l'oxygène dissous sur le relâchement de mercure potentiellement disponible pour les organismes dans des sédiments en provenance des prairies. L'étude fut réalisée à 4, 15 et 25 de 0.5 h à 30 jours. Un gramme de sédiment fut traité avec 2 mg de Hg - sous forme de nitrate de Hg. Les sédiments traités au Hg furent mélangés à de l'eau distillée déionisée. Les suspensions furent alors lavées avec un mélange d'azote et d'hydrogène 1% afin de réduire la concentration d'oxygène dissout. Les données cinétiques indiquent que le processus de désorption a obéi à la réaction multiple de premier ordre; une désorption rapide se produisit en deça d'un heure après le traitement suivi d'un processus plus lent de désorption. Lorsque le taux d'oxygène dissous passa de 4.0 ppm à 0.0 ppm, la vitesse de désorption augmenta de 1.3 à 1.9 fois pour la désorption rapide et de 15 à 26 fois pour le désorption lente. La vitesse de désorption du Hg augmenta sensiblement avec une augmentation de température. L'augmentation de la libératon de Hg fut attribuée à une augmentation de la dissolution des oxides de Fe et Mn et à une augmentation des substances organiques solubles. Ces dernières sont dues à des conditions appauvries en oxygène.

Paper: ROLE OF DISSOLVED OXYGEN ON THE DESORPTION OF MERCURY FROM FRESHWATER SEDIMENTS

Speaker: J. S. Wang, University of Saskatchewan, Saskatoon, Canada

M. Waldichuk, West Vancouver Laboratory, D.F.O.: Would you expect sulphide not to form in the sediments once dissolved oxygen has dropped to zero?

J. S. Wang: According to published information, the Eh level observed would not lead to sulphide production.

M. Waldichuk: What species of mercury forms when it desorbs from the sediments?

J. S. Wang: We measured only total mercury and not according to different species

M. Waldichuk: Can you speculate on whether other metals, eg. Cd, Cu, and Pb, would be desorbed from manganese and iron oxyhydroxides when the dissolved oxygen concentration reaches zero.

J. S. Wang: I would certainly anticipate that other heavy metals in freshwater sediments would be desorbed with manganese and iron oxyhydroxides at zero oxygen.

COMPARISON OF AN ALGAL AND A BACTERIAL BIOASSAY FOR SCREENING LAKE SEDIMENT CONTAMINATION,

P.E. Ross (1), V. Jarry (2), K. Kwan (3), B. Dutka (4), H. Sloterdijk (5)

We compare the responses of two rapid bioassays, a 3-hour algal photosynthesis test (14-C assimilation) and a 15-minute bacterial test (MICROTOX). Recent sediments from 21 stations in Lake St-Louis (St. Lawrence River) were screened using a modification of the USEPA-US Army Corps of Engineers Standard Elutriate Test. Both tests gave positive results at 16 of 21 (76%) stations. This leads us to recommend the use of the two bioassays in combination as a powerful screening procedure for lake sediments.

(1) Illinois Natural History Survey, Champaign, IL

(2) Université de Montréal, PQ

(3) National Water Research Inst., Burlington, ON

(4) National Water Research Inst., Burlington, ON

(5) Inland Waters Directorate, Longueil, PQ

On compare la réponse des deux bioessais qui sont réalisés rapidement, un test de trois heures d'une algue photosynthétique (assimilation C-14) et un test bactérien (Microtox) de 15 minutes. Des sédiments récents de 21 stations du Lac St-Louis (Fleuve St-Laurent) furent filtrés en utilisant le modificateur du USEPA-US (Army Corps of Engineers Standard Elutriate Test). Les deux tests ont donné des résultats positifs à 16 des 21 (76%) stations. Ceci nous amène à recommander l'utilisation combinée des deux bioessais comme méthode d'évaluation des sédiments du lac.

Paper: COMPARISON OF AN ALGAL AND A BACTERIAL BIOASSAY FOR SCREENING LAKE SEDIMENT CONTAMINATION

Speaker: V. Jarry, Université de Montréal, Montréal, Canada

M. Samoiloff, Bioquest International: We have wrestled with the same question, how do you take multiple tests of same sample or trying to make sense out of it, and I sympathize with your attempts to get a lot of clashes and get a lot of information out of it. But really what you're talking about is you're talking about sick or not sick, well or not well, that they are really only two cases, that you have to worry about toxic or not detected as toxic. If you do that your matrix becomes dead simple, the only thing is not quantitative all you can do is count the agreement between the two and I think you did that and on the basis of doing that according to your abstract, you said there is really good agreement, is that correct?

V. Jarry: Yes, not too bad.

M. Samoiloff: That basically, if one says it's toxic that the other also says it's toxic.

V. Jarry: Yes.

M. Samoiloff: It may be one says it's 5th most and says it's the 12th most, but there is agreement in a sense that they both say this particular material for this particular site indicates unhealthy population. That was my question.

V. Jarry: Well, where is the cue.

M. Samoiloff: That was a manifestal process but it's close enough to it?

V. Jarry: Well, I don't know, I understand you well, but it's right that if you have a test and it stuck just put on the rest line and see if you have a problem. But you have some more multiple tests that give you the same information, more useful for everybody, but injuring the life number and not too much injury. But in fact, in your case we try to make that regression between all the bioassay and the chemical variable and you find some regression which is significant. So you can see that my toxicity in Selenastrum was by arsenate, something like that, again with more information. If I can do with my micro-organism, I can see better for bacteria like this kind of problem, for algae another, and another for fish for death until you can put a flag of what kind of toxicity varies. I don't know if I answered your question.

Yves Roy, Eco-Recherche: You just said that you did that toxicity testing on five species and you just ascertained that they were best correlated.

V. Jarry: The best correlation?

Y. Roy: No. no according with the five best agreement.

V. Jarry: The best agreement? Yes, I think so with *Daphnia* and rotifers form one variable form of toxic and with bacteria this is good. It is not very surprising because the biological organizational levels are very near so probably the reason for it.

Y. Roy: What was the parameter's measure on the algae?

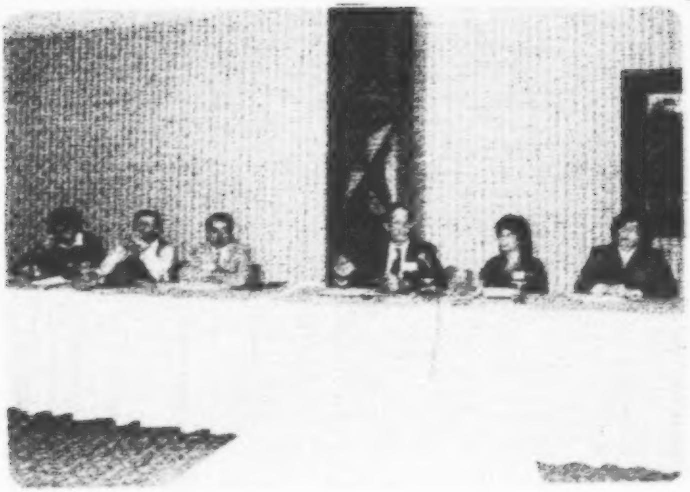
V. Jarry: See for the up-date for the photosynthesis test. It takes four hours and a very quick test.

Gerald Bouvert, Environment Canada, Quebec: I am very surprised with some of your results. I published some results on this subject some years ago. You will find them in the 7th Proceedings and I arrived at the results not comparative like yours but completely the opposite. My test was carried out eight days incubation period. I don't know how you arrived at with your results. Can you explain how you make your algal test?

V. Jarry: Sure

Y. Roy: The alga takes between one or two days to react to the shock of the lag phase. I want to know your algaltest?

V. Jarry: The test was carried out for only 4 hours period and in fact you're right, maybe I lost some information because sometime the algae take more longer. I used the C14 optic method and do not add the nutrients and measure the eye-photosynthesis rate. After that you just compare the rate at higher and higher concentrations with the control. May be, a good point that a four hours test is not enough. This year we tried some experiment and checked the difference between the 4, 24 and 84 hrs of incubation periods with electrolyte toxicity and you find that the best time for C14 uptake is 24 hours. We did not find significant difference between 24-84 hrs and the difference between 4 and 24 is good. That's right it's more sensitive, but I do not agree for the period to be 4 days, because when I used 48 hours I know I have a significant difference and I made that for a lot of tests. Maybe it's the problem of your test. Correlation or prediction is the point of my target in methodology.

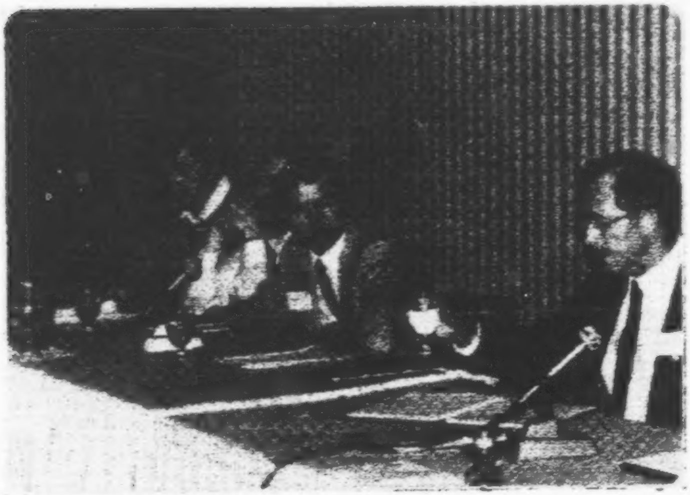


Session 4. PESTICIDES IN FORESTRY AND AGRICULTURE: EFFECTS ON AQUATIC HABITATS.

PESTICIDES UTILISES EN MILIEUX FORESTIER ET AGRICOLE: EFFETS SUR LES HABITATS AQUATIQUES.

A Panel discussion - Table ronde et discussions

EIDT, D.C., Chairman



PESTICIDES IN FORESTRY AND AGRICULTURE: EFFECTS ON AQUATIC HABITATS: Introduction: D. C. Eidt, Canadian Forestry Service - Maritimes, Fredericton, N. B. E3B 5P7

The purpose of the session was to address the general topic of pesticides originating from agricultural and forestry management practices and the risk to aquatic organisms.

The approach was to have persons with different points of view address the topic. Selected were agriculture and forestry, the resource interests seen to be at fault, the fisheries resource interest seen to be the victim, the pesticide industry seen to represent the heartless moneymaker, and the environmental people who are impartial good guys from one point of view and witch hunters from another. This mix provided thought stimulating controversy and a surprising convergence of attitude and opinion.

AGRICULTURAL PESTICIDES IN THE AQUATIC ENVIRONMENT RISKS VS. BENEFITS: J. E. Hollebone, Issues, Planning and Priorities Division, Pesticides Directorate, Agriculture Canada, Ottawa, K1A 0C6

Pesticides are essential agricultural production tools for many crops. They may reach aquatic environments by several routes. The magnitude of effects depends upon several factors including environmental chemistry and fate, quantity, and toxicity of pesticide to aquatic organisms. The concept of acceptable balance between use and safety to the environment is discussed. Technological advances allow detection of aquatic contaminants at very low levels. The regulation of pesticides involves weighing risks and benefits, and science-driven decision-making. Cooperation of the sometimes conflicting interests of agricultural use versus environmental protection is essential. Alternatives to pesticide use are discussed.

RISKS TO AQUATIC ORGANISMS FROM FORESTRY PESTICIDE USE IN CANADA: Peter D. Kingsbury, Forest Pest Management Institute, Canadian Forestry Service, Sault Ste. Marie, Ontario, Canada P6A 5M7

Current forestry uses of insecticides and herbicides pose far smaller risks to aquatic organisms than generally perceived by the public, special interest groups and pesticide regulators. This is due in part to numerous changes in forestry pesticide use, primarily in the amounts and types of pesticides used and the manner in which they are being applied. Overall decreases in quantities of forestry pesticides applied, large increases in the proportion of biological insecticides used, more precise targeting of smaller forest blocks for treatment, increased use of smaller aircraft and helicopters, observance of spray buffers around aquatic systems, increased training and regulation of applicators and greater sensitivity among forest managers for concerns about pesticide use have all contributed to decreased risk of harming aquatic systems. The toxicity of currently use forestry pesticides to aquatic organisms and the levels and duration of their exposure following normal use are such that direct effects on fish are highly unlikely and impacts on aquatic invertebrates are generally absent, modest or of short duration. Secondary effects on fish from normal forestry insecticide and herbicide use seem equally improbable.

NEED FOR PESTICIDES FOR FOREST AND AGRICULTURAL PRODUCT PRODUCTION: M. Gadsby, Hoechst Canada Inc., Regina, Saskatchewan, Canada S4N 6C2

The need for pesticides in the economic production of agricultural and forest products is certain. The need for maintenance and protection of fragile environmental resources is also obvious. The resolution of these sometimes conflicting concerns can only be accomplished through critical assessment of both the risks and benefits of pesticide use. Reasonable compromises can be made that assure continued agricultural and forest production while minimizing ecological disruption.

Goverment and industry need to work together to assess both the potential for environmental hazard through continued research and to establish reasonable guidelines for pesticide use based on practical considerations.

THE DEPARTMENT OF FISHERIES AND OCEANS' ROLE IN PESTICIDE REGISTRATION: W. L. Lockhart, Canada Department of Fisheries and Oceans, Central and Artic Region, Freshwater Institute, 501 University Crescent, Winnipeg, Manitoba R3T 2N6

Under Canadian Law, the registration of pesticide uses in Canada is the responsibility of the Department of Agriculture. In view of a history of cases in which pesticides have had an impact on fish and on invertebrate animals, cooperative arrangements have been developed to allow the Department of Fisheries and Oceans to review those pesticide applications with potential implications for fish or fish habitat. The Departement of Fisheries and Oceans does not have a veto power over the final decision by Agriculture Canada, and registration has been granted in spite of our objection. The mandate of the Department of Fisheries and Oceans is derived from the Fisheries Act, which requires the Department to protect fish and fish habitat from inputs of chemicals harmful to them. In addition to the regulatory role in reviewing pesticide applications the Department maintains a small research component conducting research on the toxicology and environmental chemistry of pesticides.

ASSESSING AND REGULATING THE ENVIRONMENT EFFECTS OF PESTICIDE USE: W. R. Ernst, Environmental Protection Service, Environment Canada, Darmouth, N. S., Canada B2Y 2N6

The regulation of pesticides poses unique problems. Pesticides are the only chemicals in commerce that are selected on the basis of their anti-biological properties and are released intentionally to the environment to produce their desired effects. As in most other industrialized countries, Canada has established an elaborate system to evaluate prospective pesticide chemicals prior to their introduction to the marketplace. The ability of this system to screen out problem chemicals prior to their registration has improved with the increase in the sophistication of predictive toxicological evaluation.

Pre-registration systems will never be "fail-safe", however, the magnitude and frequency of environmental problems associated with pesticide use has decreased in recent years. There also remains, however, a serious lack of dedication of effort to monitoring the impacts of pesticides under operational use. Some regulatory/assessment agencies are attempting to address this problem through new legislaton and program initiatives.

Le but de cette session est de traiter de façon générale le sujet des pesticides originant de pratiques agricoles ou forestières et les risques encourus par les organismes aquatiques.

Des personnes avec différents points de vue discuteront du sujet. Les points soulevés seront l'agriculture, la foresteries, les intérêts fautifs en cause, les intérêts de la ressource vue comme victime, l'industrie des pesticides vue comme n'ayant que l'argent en tête et les groupes environnementaux vue comme impartiaux par certains et comme chasseurs de sorcières par d'autres. Tout ceci devrait soulever beaucoup de controverse et engendrer de bonnes discussions.

Il est sûr qu'il existe un besoin de pesticides dans la production économique de l'agriculture et de produits forestiers. C'est une nécessité pour le maintien et la protection des ressources environnementales fragiles qui nous entourent. La résolution de ces intérêts souvent conflictueux ne peut être accomplie qu'à travers une évaluation critique des risques et des bénéfices de l'usage des pesticides. Des compromis peuvent être faits. Ils assureront la continuité de productions agricoles et forestières ou en minimisant l'impact des pesticides sur les milieux écologiques.

Le gouvernement et l'industrie sont dans l'obligation de coopérer afin d'évaluer non seulement le potentiel du danger environnemental à l'aide de recherches continues, mais aussi pour établir des clés d'utilisations raisonnables pour les pesticides basées sur des usages pratiques.

La règlementation des pesticides pose des problèmes uniques. Les pesticides sont les seuls produits chimiques commerciaux qui sont sélectionnés d'après leurs propriétés anti-biologiques et qui sont relâchés dans l'environnement intentionnellement pour produire les effets désirés. La Canada, comme la plupart des autres pays industrialisés, a élaboré et établi un système d'évaluation de pesticides chimiques avant leur introduction sur le marché. Avec une évaluation de prédiction toxicologique plus sophistiquées, la capacité du système à identifier des produits chimiques-problèmes avant leur introduction sur le marché s'est améliorée. Des systèmes de pré-enregistremets ne seront jamais fiables à 100 p. cent. Cependant l'ampleur et la fréquence des problèmes environnementaux reliés à l'usage des pesticides a diminué pendant les dernières années. De plus, il existe toujours un manque sérieux d'effort de monitoring des impacts des pesticides sur leur terrain d'application. Certaines agences de règlementation/évaluation tentent d'adresser ce problème par de nouvelles lois et de nouveaux programmes.

L'utilisation courante d'insecticides et d'herbicides en foresterie pose aux organismes aquatiques des risques beaucoup moindres que ce qui est généralement perçu par le public, les groupes d'intérêt spécial et responsables de la règlementation des pesticides. Ceci est dû en partie à plusiers changements dans l'usage des pesticides en foresterie, principalement dans les quantités et les types de pesticides utilisés et dans leurs méthodes d'application. Plusieurs facteurs ont contribué à réduire le risque de tort aux organismes aquatiques par les pesticides: une diminution générale des quantités de pesticides appliqués, une grande augmentation dans la proportion d'insecticides biologiques utilisés, des objectifs plus précis de traitement de blocs forestiers plus petits, une utilisation accrue de petits avions et hélicoptères, un respect de zones tampons autour de systèmes aquatiques, une augmentation dans l'entraînement et la règlementation des applicateurs et une plus grande sensibilité des aménageurs(euses) forestiers(ères) par rapport l'utilisation des pesticides. La toxicité des pesticides forestiers présentement utilisés ainsi que leurs niveaux et leur temps d'exposition suivant une utilisation normale sont tels que les effets directs sur les poissons sont très improbables et le impacts sur les invertébrés aquatiques sont généralement absents, modestes ou de courte durée. Les effets secondaires d'utilisation normale d'insecticide et d'herbicide forestiers sur les poissons semblent aussi improbables.

SUMMARY

D. C. Eidt,
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The registration process for pesticides in Canada is strict, even stricter than that for pharmaceuticals. That is as it should be because pharmaceuticals presents a risk only to the treated individuals, whereas pesticides present a risk to entire communities. Strict as the regulations may be, they are subject to the simple principle cited by Lyle Lockhart, which, stated another way, says that if something is convincingly demonstrated it is proven, but something not demonstrated is not disproven. Thus the constant vigilance and cooperation of all organizations concerned about the benefits and hazards of pesticides is needed. There is everything to be gained or maintained, because environmental protection (in the context of this symposium, protection of the aquatic habitat) is in everybody's best interest. Agriculture and forestry cannot risk the loss of pesticides as critical tools of production; industry cannot risk the loss of products in which it has invested millions of dollars.

A sixth element in the pesticide controversy, for which we do not have a spokemans, in this symposium, is public opinion, and in particular the environmentalists who purport to represent it. That is not to say that Environment Canada is insensitive to public opinion, but the response is indirect through government and departmental policymakers. Environmentalists have been keen watchdogs whose concerns have led to many changes in the way pesticides are regulated. Once ruled more by emotion than rationality, it is my observation that they have become increasingly sophisticated, and like scientists, businessmen, and resource managers in fisheries, agriculture, forestry, the chemical industry, and government, are becoming increasingly aware of the benefits and costs and conflicts of interests involved in pesticide usage.

In summary the panel agrees on several matters:

1. Pesticides will be with us into the indefinite future, and we will have to cope with them in aquatic habitats because of the ubiquitous nature of water.
2. We have a good pesticide regulatory process in Canada that is constantly improved.
3. National regulation may not be good enough for us and our neighbors. We have to think and regulate hemispherically or even globally.
4. The regulatory process is not perfect, but it will continue to improve. A system based on antagonism is not the best way to improve it.
5. The environment is not negotiable. One cannot put a price on some things, and the trade-offs will be judgmental rather than cost-benefit exercises.

Much of the body of data in a registration package is not available for postregistration scrutiny. Therefore persons concerned about possible environmental (or health) effects must start many of their investigations from the beginning, and are compelled to repeat work already done. This being so, there was an underlying thought in this Symposium that was pointed out to me by may associate and graduate student, W. L. Fairchild. It involves philosophical differences in approach to study of environmental side effects: before registration, emphasis is on environmental safety and after registration, emphasis is on environmental hazard. Furthermore, evidence of the invalidity of a registration is taken seriously before registration and may delay or prevent it (guilty until proven innocent), but after registration, similar evidence will be vigorously opposed, has little chance of resulting in suspension of the registration, and may require a protracted conflict before deregulation or suspension occurs (innocent until proven guilty).

From what we have heard, things are changing, and products and formulations that were registered in the past are being reexamined using current, more rigorous procedures. Most registrations will probably be confirmed, but many may be deregistered. Let us hope that registrations which cannot meet the current criteria are found before serious environmental damage occurs.

GENERAL DISCUSSION

Edited by D. C. Eidt

Douglas Eidt, Canadian Forestry Service-Maritimes.

I would like to start the discussion by pointing out that one of the solutions we can look forward to is a movement towards, for want of a better name, "biorationals". Biorational pesticides are pesticides that are nearer to the natural. Bacillus thuringiensis, for example, is a naturally occurring soil bacterium. There are other naturally occurring organisms such as viruses, fungi, and nematodes that may become available. There is biological engineering, receiving much publicity as something in the future, but there have been some remarkable successes in the past. For example, breeding of wheat resistant to wheat stem sawfly was very successful years ago as a totally nonpolluting tactic.

One of the things that has not been mentioned is the cost of introducting new agents, chemical or otherwise, and the hurdles that the registration process erects. The process through which a company must go to get a product on the market is horrendous and expensive. In fact I understand that some companies are getting out of pesticides because the capital risk is too great. How then is the new generation of pesticides going to happen? Who is going to do the research? The federal government seems less and less interested in research as time goes on and all of us in federal departments have been taking cuts without too much attention to the importance of what we actually do.

Jean Hollebone, Agricultural Canada:

The Entomological Society of Canada published in June 1976, a document on microbial products that can be used as pesticides*. In the document they estimated that the cost of an environmental and toxicological safety package to support a microbial or rational product was about $500,000. This is lower than the cost for a traditional chemical pesticide, for which the estimate of the chemical industry, based on 1985 data, is 20 to 25 million. The reason is that the type of testing is different. Agriculture Canada does not require long-term safety studies for microbial pesticides because it is now felt that these are agents that cannot cause cancer or birth defects.

Who's going to pick up the cost of this research? I think the answer is that it will come from both the private sector and from government. From example, at their Saskatoon Research Station, Agriculture Canada is currently paying for testing of Nosema locusti, a protozoan agent that kills grasshoppers. I believe that Environment Canada has put some money into the testing. Elsewhere a number of phylloplane fungi are being studied and the cost is being sponsored partly by government, partly by industry.

Bill Ernst, Environment Canada:

I have had a chance recently, Dr. Hollebone, to look at testing procedures for microbials and biologicals and, correct me if I'm wrong, but it's a tiered system with the lab toxicological work being tier one and field studies being tier two. You don't move on to tier two until you've demonstrated a negative effect in tier one. It bothers some people in Environment Canada that you could possibly register a biological pesticide without doing a field evaluation of it.

Jean Hollebone:

No, that would not be done. In fact, all of the microbials that have been registered have been field tested in Canada before registration. Tier one and tier two testing now go on almost simultaneously. I cannot foresee that we would agree to a registration without Canadian field trials. In fact, this has been carefuly written into the Canadian guidelines. Even for chemicals, we require Canadian field trials for both forestry and agricultural pesticides. I am sure B.A.S.F. would have been interested in hearing what you had to say earlier because I have held up registration of one of their products for three years while waiting for environmental testing to be completed.

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*Morris, O.N., Cunningham, J.C., Finney-Crawley, J.R., Jaques, R.P. and Kinosita, G. 1986. Microbial insecticides in Canada: their registration and use in agriculture, forestry and public and animal health. Entomological Society of Canada, 1320 Carling Ave., Ottawa, Canada, K1Z 7K9.

Peter Kingsbury, Forest Pest Management Institute:

The Department of Fisheries and Oceans has recently made public a "Policy for the Management of Fish Habitat" which has the objective of increasing the productive capacity of Canada's fish habitat. To achieve this, it states that the Fisheries Act will be strictly administered and enforced so that there is no net loss of habitat due to alteration by chemical, physical, or biological means. What kind of pesticide effects would you consider to result in the kind of loss of productive capacity of habitats which the policy is aimed at preventing?

Lyle Lockhart, Fisheries and Oceans Canada:

I haven't seen the final policy statement. I did see drafts on several occasions and I think the intent is to deal with both physical and chemical habitat destruction. Among chemical effects, I think there are two. One would be measurable change in production rates such as fish growth or fish abundance; the other would be change in the quality of the product. The latter might not just be fish but also shellfish and marine mammals and it means quality due to the presence of a chemical such as a pesticide or some component of a formulation that would be objectionable to consumers. The difficult part, of course, is measuring change in productivity and the statistical problem of distinguishing it from natural variation. It is still a subject we do not know how to handle very well, except in a few extreme cases of virtual extinction in reaches of a stream. There is no easy answer to the question.

Peter Kingsbury:

I think that is a reasonable policy and one with which I have no arguments. Measuring fish production in the field and relating it to effects of a specific chemical is obviously a difficult thing to do, but it is still the ultimate criterion and the one I would want to see used in implementing the policy.

Lyle Lockhart:

Dr. Hollebone, are there provisions in the Pest Control Products Act for penalties for people who do not use pesticides in the prescribed manner, and have you prosecuted people for violations?

Jean Hollebone:

Yes, there are provisions in the Act. There are no specified penalties, just that the Minister may prosecute if he sees fit. I don't know if we have prosecuted or not. Most prosecutions for pesticide use infractions occur at the provincial level.

Douglas Eidt:

Would you say Ms. Gadsby, that in general most companies involved in manufacturing pesticides take the same enlightened attitude toward environmental questions that yours does? I would like to think that all were as good.

Margaret Gadsby, Hoechst Canada Inc.:

We are Hoechst take a stance, that, in many cases, is different than that of our competitors. We pride ourselves on the job that we are doing and naturally like to take advantage if our competitors are not as involved. I think that I would have to say that some of our competitors are not as environmentally concerned. Of all the people I know in industry I know of no one who has a job description comparable to mine. There are certainly other companies involved in projects of an environmental nature in Canada and there is certainly an outlay of capital from other companies but I do not think it is as significant as what Hoechst is now doing. That may be partially a reflection that the environmental fate guidelines and the registration process have been in flux. Right now, Hoechst has a policy of trying to do things before it is demanded of us. That is not a policy held by all chemical companies some of which with until they are absolutely forced to do a certain thing. I don't believe that attitude does anybody any good.

Jean Hollebone:

Dr. Lockhart, you indicated that it is not good enough to say that toxaphene be banned, which is true. It is now deregistered in Canada and most uses are deregistered in the United States. But you indicated that there are still problems with toxaphene pollution in fish and in the environment. I understand too that a lot of toxaphene is volatilized in the atmosphere, which is the same with chlordane and perhaps DDT. What should be done about it and who should do it?

Lyle Lockhart:

With toxaphene it is probably what we should have done, not what we should do. We probably ought not to have let the quantities loose in the hemisphere that we did, and that would not have been a Canadian decision. We have to learn to think more hemispherically than nationally and that's going to take a long and difficult time. Several recent issues, PCBs, acid rain, certainly some of the heavy metals, polyaromatic hydrocarbons and now perhaps toxaphene, all argue that it is not good enough to act nationally. Canada is going to have to make its voice known internationally to try to get other countries to regulate things that may affect us.

Some people think that the northern latitudes function essentially as a cold trap, where things go in and once there they cannot readily get out. If that is so, then parts of Canada are something of a sink for the materials coming from the rest of the hemisphere. An interesting example is bomb fallout, where levels of radioacticity have become higher in Arctic sites than in central latitude sites. The evidence indicates a kind of process, at least in the Far North, by which we can expect things to accumulate there, and once there, there is nothing we can do about it.

The only action is prevention. Some minor solutions to this pollution may be possible in the processing of certain northern products, but in the subsistence fishery, there is little that can be done once the chemical is there. One just has to wait for it to go away quietly and that is not going to be fast.

There was an abstract in the program for the 1986 SETAC meeting from Dr. Matsumura's lab, which indicated that he had found a way to get the toxaphene out of fish flesh. He was dealing with weathered toxaphene, which does not have all the approximately 180 components that fresh toxaphene as, but apparently it still retains the toxicologic properties. There is not much that can be done and those who pay the price are going to be the fish and the consumers. Hindsight is fine but I do not know what we can do about toxaphene or chlordane aside from monitoring and knowing where we stand. We must use this hindsight to try and do better in controlling new products.

Keith Holtz, Ontario Ministry of the Environment:

I think that in the United States the rising costs of agriculture has forced some farmers to stop applying pesticides. In some cases, this has turned out to be a success for them, because they have created a market for contaminant-free produce and the public is willing to pay a higher price for it. Has this sort of success occurred in Canada and has it posed any questions about the widespread use of pesticides in agriculture?

Jean Hollebone:

Agriculture Canada did a survey of organic farming in 1985 and I believe it constituted about 6% of the total. Certainly for some specialized crops, organic farming is feasible in Canada. To convert from total chemical dependence to total chemical independence it has been estimated that there would have to be a subsidy for the first two to three years to allow changeover to occur, and that within 5 years organic farming would be profitable for some crops.

Stella Swanson, Saskatchewan Research Council:

Ms. Gadsby, given the inevitability of pesticide use, at least in the foreseeable future, would you please outline Hoechst's programs to promote a conscientious and responsible use of its pesticides by farmers?

Margaret Gadsby:

One of the main sales methods is growers' meetings or farmers' meetings held through the winter months. Depending on the province and crop they are held in different ways. Often they are open forums where one representative from each of the pesticide manufacturers gives a 15-minute presentation on their particular products. This is followed by an open question period. At many meetings of this kind there is a lot of technical information on proper use, given by sales people and field representatives. Specific topics are addressed either by the local agricultural fieldman, the local provincial agricultural representative, or others. There are also talks by representatives of the Crop Protection Institute of Canada (CPIC), and although the speaker is an employee of one company or another, on that particular day he wears a neutral hat and talks about neutral subjects such as triple rinse procedures, or how to dispose safely of pesticide containers. All the pesticides companies are involved in this type of education program.

Other programs are sponsored through the CPIC. Brochures were prepared on triple rinse procedures and on disposal of pesticide containers. Coloring books are distributed to public schools of the Prairies. Slide presentations are given in high schools to promote safe use of pesticides. We hope they will go back home and pressure dad if he is not wearing his respirator. There are many film productions, of CPIC jointly with provincial departments of agriculture, available to interested groups. In the spring of 1987 CPIC will begin distributing stick-on labels reminding farmers to wear protective clothing and equipment. The

CPIC is also active in eastern Canada, and I assume similar programs are in place there.

In 1987 Hoechst will place a "Protect your crop, protect yourself" logo on all pesticide containers, advertising, and labels to emphasize the importance of wearing proper protective gear. We will also subsidize the cost of Pesticide Safety Kits to be sold through the Prairies 4-H Clubs.

Another thing many of use are doing is related to Bill Ernst's earlier reference to information accessibility. Many of us in the industry are producing, what we are calling for lack of a better name, product monographs on each of our chemicals. We are waiting for guidelines from Agriculture Canada on what exactly should be included in them, and we hope to have them available soon. Hoechst is trying to include more information than that contained in our technical literature. It will have toxicity data, chemical and physical properties, and explanations of what those things mean. It will also have more detailed descriptions of pesticides fates in all the environmental sectors or which we have information, such as the fate in different soils, the dissipation times, the leaching characteristics, etc. It is a huge task to condense what is contained in numerous volumes and put it into language that everybody can understand, but I believe it is a worthwhile project.

Ray Côté, Dalhousie University:

I was concerned after hearing Jean Hollebone's and Bill Ernst's remarks that there seems to be some confusion as to whether Environment Canada and Fisheries and Oceans are getting all the information that they want from the registration process. I would like to have that clarified.

Bill Ernst:

I was surprised by the reaction to some of the things I said. Perhaps there is a sensitivity that I had not appreciated.

Most of my criticism dealt with the Environment Canada response to pesticide registrations. We, as Jean Hollebone indicated, have not been up to strength for quite some time. There was quite a while between 1980 and 1982 when we weren't doing any pesticide evaluations at all.

I did not mean to indicate that we were not getting the information from Agriculture Canada. All I meant is that without a formal Memorandum of Understanding all information is forwarded to us at Agriculture Canada's discretion. I think that is unsatisfactory from a strictly environmental point of view. If there is a need for an environmental voice then the procedure should be formalized, and not left to the discretion of such a loose relationship. That there has been a Memorandum of Understanding in the works for almost five years, indicates that it is more than just a problem of getting two bureaucrats together to sign it. I was trying to say it needs to be done now.

Jean Hollebone:

Dr. Khan, would you clarify the position of Fisheries and Oceans on this issue. Do you feel that Agriculture Canada withholds data from Fisheries and Oceans? Are all the data that come in from registrants provided for your review?

Dr. Nuzrat Khan, Fisheries and Oceans Canada:

Yes, they are. I don't think you hold back data but the type of data that is requested after the preliminary review of the submission at times is not generated, or it takes a long time to be generated. There is quite a bit of resistance on the part of industry to generate that kind of data. I know that there have been disagreements, violent disagreemets, on protocols. We did not accept certain protocols, industries went ahead anyway. The data came back and we rejected them. This is the sort of thing that has happened in the past and I believe the guidelines might eventually alleviate this kind of problem. Certainly Agriculture Canada doesn't hold back any data. All data that you receive from the industries are available to us.

Margaret Gadsby:

In your remarks, Dr. Khan, you alluded to hostility or hesitation by industry to answer environmental questions. There are two aspects to it and I don't think they should be confused. Firstly, you said that it takes a long time to get requested data, which is not hostility at all. It involves logistics. It is obviously in our best interests to do whatever is necessary to get our products to market at the earliest possible date. There is no motivation to stall procedures. Bill Ernst already referred to the problem of how few people are available to do the work. Enough people have already stated that it is not acceptable if many studies are done by industry. It is not easy to find people at the drop of a hat to do research that has to be done in Canada in the current season. It often takes us at least a year to find somebody to do the work.

The other point to which you alluded is the difficulty of dealing with protocols. I also alluded to it in my presentation when I said that sometimes we get adversarial. Instead of sitting down with us and coming up with protocols that are logistically feasible and scientifically important, the advisors have often generated protocols that cannot be physically carried out. For example, sometimes these advisors visualize sloughs as circular waterbodies on essentially flat land, remote from farm buildings and other complications, but I for one have yet to see such perfect experimental sites. These are real logistic concerns that have to be addressed. Working cooperatively in developing protocol is really the only feasible way to get the work done. Obviously, we do not have the expertise in industry to establish good protocols without environmental comment, but we do have some expertise. We do know what the study sites are like and we do know what the typical agricultural practices are. We would be pleased to be involved in cooperative efforts to establish protocols that we have the ability to follow.

Dr. Nuzrat Khan:

Margaret Gadsby said that the Canadian registration system is either the most, or one of the most, stringent in the world. I would like to know her basis for this statement. If the basis of this statement is a comparison of systems in the different countries, I would like to know what other countries were compared with Canada.

Margaret Gadsby:

It was not necessarily a statement on the systems *per se*.

It is difficult to compare registration systems because one has to consider the time for submission to registration, and that is often a political issue. From information that comes from our parent company, which supplies Hoechst subsidiaries in countries throughout the world, Canada, Japan, and the United States make the greatest demands for data. These countries require the greatest number of studies, the most replication of studies and the greatest proportion of studies that must be conducted within their own boundaries. Many studies are not acceptable to these countries if done elsewhere in the world.

Margaret Taylor, Environment Canada:

At one time I was looking at the adverse effects of drugs, drugs that had already been proven to do what they were supposed to do, just before they went to clinical trial. The development of one drug was completely stopped because, by chance, we happened to use a species of animal that is not normally used. The animal went blind. None of the other regularly used animals showed any effects even down to the cellular and biochemical levels. There is always something that slips through.

Is Agriculture Canada convinced that a wide enough range of non-target organisms is being used in toxicity testing for registration and reevaluation purposes?

Jean Hollebone:

We do not yet have ecotoxicology guidelines produced by the regulatory authorities. As soon as we complete the environmental fate guidelines, I would hope to deal with the problem. The Canadian Wildlife Service is already putting some effort into such guidelines.

I personally do not have many concerns that the rang of species we are testing is not wide enough, because most of our field studies are done with common Canadian species, and that is an unstated requirement that has been our policy for some time.

When we do get a protocol for a field study, it is always sent to the environmental advisors for review. If they see something that is not indigenous, they have the opportunity to suggest that another species be used. Sometimes it takes us a while to determine what would be the best species to use. In the methoxychlor studies on the Saskatchewan River, for instance, goldeye, Hiodon alosoides (Rafinesque), was used as the monitor species and, as Lyle Lockhart can confirm, because of the habits of this particular species it was determined that it was not the most appropriate one. Crayfish, which are much more sedentary, and a sediment-feeding sucker were chosen as more suitable species. In both cases, we were considering Canadian species, but we had to revise the choice to refine our knowledge of possible impact.

Yes, I am quite happy with the species that are being chosen, but I would not interfere with the advice of environmental advisors on this point.

Ken Thompson, Water Quality Branch, Environment Canada:

Firstly, I'd like to follow up on a point that Margaret Gadsby made earlier about communication and public relations. For too long my particular group has been concerned with collecting little bottles of water, having them analysed, and putting the results on a shelf. We have not considered public information programs. We have not gone into the schools to talk to children to ask them to think in the kind of terms that Dr. Lockhart has been urging us to think - the hemispheric approach.

Secondly, I'll have to take issue with Bill Ernst, my colleague from Atlantic Canada. I don't think some of the problems lie entirely within Environment Canada, although I may be wrong. Consider an example of what I call lack of coordination. This summer it came to light within the Western-Northern Region that Agriculture Canada had been undertaking a drinking water survey. The problem of us not knowing about it may lie within our own department, but not only did we not know about it, the provinces of Alberta and Saskatchewan did not know about it.

Finally I would add a further clarification on a point that Bill Ernst made about the number of person-years devoted to pesticide monitoring. I have to talk about toxic chemical monitoring, because I cannot say how much is pesticides. Within my region, which includes the three Prairie Provinces and the Northwest Territories we have at least 8 person-years devoted full-time to the monitoring, sampling, study, and analysis of toxic chemicals.

Bill Ernst:

The figure of 8 person-years in Environment Canada comes from a recent submission to Treasury Board requesting additional person-years to assess and monitor pesticide use. That is all I have to fall back on. I am certain there are parts of person-years everywhere that are used for pesticide residue testing but may not have been accounted for in that figure.

Lyle Lockhart:

I have a question which derives from queries I get from provincial agencies, particularly in Saskatchewan and Manitoba about the use of herbicides for conifer release. I know that use seems to be growing on the Prairies and I have heard it is growing on the eastern slopes of the Rocky Mountains. I wonder if Peter Kingsbury could tell us what the future holds there.

Peter Kingsbury:

I am going to be hard pressed to come up with actual numbers but I will try. First let us consider that there is a serious forest regeneration gap in Canada, and we have to turn things around in forestry. One of the things that kind of talk is doing is giving the feeling, particularly amongst the public, that all of a sudden forest management is going to become very intensive on many sites. The reality of course, constraints of economics being what they are, is that it is certainly going to take a long, long time to take place, although that is a goal.

In British Columbia, of the area harvested, usually about one-third regenerates naturally and it is not necessary to do anything. About one-third of the sites requires some kind of intervention. Planting is one of the most common ones, sometimes combined with site preparation, and may or may not involve herbicide use. About one-third of the sites just go to waste because we do not do anything and they do not sufficiently regenerate. That is where the gap occurs. Thus in northern Ontario sites taken out of black spruce or jack pine production become mixed woods of poplar and conifers with very little commercial value.

In British Columbia, of the sites that require treatment, they say they can deal with a large proportion of them without using chemical vegetation control methods. They can use fire, mechanical site preparation, and in some cases mechanical or hand clearing. Thus only a proportion of the sites requires chemical control by herbicide. The main constraint on the areas treated is, of course, the money available.

Another constraint results because these sites and applications have to be individually licensed by the provincial environment agencies who sometimes limit what can be done. For instance, when glyphosate was registered for aerial forestry use for conifer release in British Columbia, suddenly provincial foresters and a chemical vegetation management tool that appeared to have some promise in the coastal region, something they had been without since 2, 4, 5-T was taken from them. Applications for permits for 15,000 ha over a three-year period were submitted to the Department of Environment. The Department requires an onsite inspection of each of these sites so that they can make specific recommendations for setbacks and soon. Largely because of their manpower constraints they were able to issue permits for only about 5000 ha. The area sprayed was actually somewhat less. So there are many constraints on the scale of herbicide use.

It has been suggested that future forest herbicide use in Canada might exceed 250,000 ha/yr. Current use is probably close to 100,000 ha/yr. Good figures are hard to get because applications are made by a large number of regional forest managers, forest industries, and private woodlot owners rather than by centralized provincial agencies as is usual with forest insect control. In addition, herbicide use figures often do not distinguish between aerial sprays, ground sprays and hand applications such as stem-injection, which obviously pose different degrees of hazard to adjacent aquatic systems. For forest herbicide use to greatly increase, it would require registration of some new herbicide options and a good forest economic climate that encourages greater investment in forest management, which is not now so because of the U.S. softwood import tariffs. At present, in some areas, we have 2, 4-D and glyphosate for aerial application, and 2, 4-D has big cloud over it. Glyphosate has limited uses and does not work well in some siuations. New materials being developed have many environmental and regulatory hoops to get through. If the materials are not available they will not be used. Thus, forecasts of increased use over current levels may not materialize.

There may be specific situations in parts of the country where herbicide use is almost routine. Where there is intensive management of a specific crop with a specific competitor it may be impossible to establish a crop without using a herbicide. Future use partly depends on what the provinces will do in terms of initiatives and incentives for the forest industry to reinvest money and regenerate sites.

Douglas Eidt:

Money invested in forestry in this way, where one does no reap the benefits until 40 to 80 years later, has to be written off now. It has to be charged against current profits and as the industry prospers or slumps, the amount of investment in the future crop changes. The industry cannot amortize money over the next 20 years because it cannot afford to. This contrast sharply with agriculture, where the crop is nearly always harvested in the year of treatment.

Peter Kingsbury:

I have a question for Lyle Lockhart. What would you estimate is the total magnitude of annual fish kills caused by agricultural and forestry pesticide use in Canada? What pesticide uses appear to cause most of these?

Lyle Lockhart:

I usually get only one or two reports every year and I presume they get similar reports in other regions. Most reports of that sort would probably go to provincial fisheries agencies and I might or might not hear about them. They have usually been examples not of intentional misuse but of careless misuse.

In one 1986 incident in Dauphin, Manitoba, the municipality sprayed with malathion and almost at the same time property owners along the river did so too. The river received a double dose within a short time and that caused a kill for a few miles of river. Another incident was reported by some cottage owners who were opposed to chemical use and who found many dead fish at about the same time the weeds disappeared from some of their neighbor's docks. It was suspected that some weed control chemical had been used in the water, but no one knew what it was, or for certain who was responsible.

Unfortunately we do not have a good veterinary pathologic type of ability to diagnose particular causes for dead fish. The best samples would be those where the fish are moribund but not dead. If they were frozen or reserved quickly they would be useful for some pathological examinations but that rarely happens. We did make a concerted effort in 1986, through Agricultue Canada, to find specimens of fish killed by pyrethroid use. Jean Hollebone may know if some were found, but none came to my attention although the various Agriculture Canada stations were to let me know if they suspected such a thing. That opens a difficult one-way argument. There is delightful quote, and I can't remember who said it, which says, "Absence of evidence is not evidence of absence". There may be many things going on that just never reach our attention.

Session 5. FISH EPIDEMIOLOGY AND POLLUTION EFFECTS ON AQUATIC BIOTA.

EPIDEMIOLOGIE DES POISSONS ET EFFETS DE LA POLLUTION SUR LES BIOTOPES AQUATIQUES.

PARKER, W.R., and G. OZBURN. Chairpersons

TOXICANT AVOIDANCE TESTS WITH PLATING INDUSTRIAL EFFLUENT,
J. Hadjinicolaou and L. D. Spraggs, Department of Civil
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An extensive review of all the avoidance apparatuses which have been used to date in chemical avoidance tests and also an analysis of the trends and needs for new improved designs led to the design of a new apparatus. The new apparatus is a viable tool for analyzing the behavioural response of fish to potentially toxic effluents in three dimensions. The method is quick, sensitive and relatively easy to use if sufficient stock is available. The type of the pollutant used was a plating industry effluent. The variable parameter of the avoidance reaction was the concentration of the pollutant. Statistical analysis for the experiments included preliminary calculations, time series analysis, analysis of variance and Duncan's tests. Horizontal and vertical distribution curves throughout the channel were produced together with avoidance curves and avoidance reaction representations. Finally, the role of the avoidance reaction in relation to lethal and sublethal levels has been defined.

Une étude approfondie de tous les appareils utilisés jusqu'à maintenant dans les tests d'évitement de produits chimiques ainsi qu'une analyse des tendances et du besoin de meilleurs appareils ont suscité la conception d'un nouvel appareil. Ce nouvel appareil constitue un excellent outil pour l'analyse tri-dimensionnelle des réactions des poissons aux effluents toxique. La méthode est rapide, sensible et d'usage relativement aisé si le stock de poissons est suffisant. Le polluant utilisé est un effluent d'industrie de placage. La variable de la réaction d'évitement était la concentration de polluant. Les analyses statistiques utilisées dans les expériences comprennent des calculs préliminaires, des analyses de série temporelle des analyses de variance ainsi que les tests de Duncan. Les courbes de distribution horizontale et verticale sur la longueur du canal ont été effectuées ainsi que les courbes d'évitement et les représentations de réaction d'évitement. Finalement, le rôle de la réaction d'évitement est défini aux niveaux létaux et sous-létaux.

Paper: TOXICANT AVOIDANCE TESTS WITH PLATING INDUSTRIAL EFFLUENT

Speaker: J. Hadjinicolaou, Dept. of Civil Engineering and Applied Mechanics, McGill University, Montreal, Canada

C. Morry, D. F.O., Moncton: Did the author examine carefully the possibility that avoidance reaction may have been in part due to high light used for video recording.

J. Hadjinicolaou: Yes, studies were done with pollutant injected both on the side where lights were present and the other with little difference noted.

DISTRIBUTION OF ARSENIC AND MERCURY IN ZOOBENTHOS FROM THE SHUBENACADIE RIVER HEADWATER LAKES IN NOVA SCOTIA. Janice L. Metcalfe and Alena Mudroch. National Water Research Institute, Burlington, Ontario. Canada L7R 4A6

The Shubenacadie River headwater lakes near Halifax, Nova Scotia, are contaminated with arsenic (As) and mercury (Hg) as a result of past gold mining activities near the town of Waverley. To determine the extent of ecosystems contamination, and to select suitable organisms for biomonitoring, benthic invertebrates were collected from five of the lakes in 1984 and 1985. Chaoborus sp., Chironomus sp. and Oligochaeta were obtained from the deep zones of the lakes, while the snail, Helisoma sp., and the mussels, Anodonta implicata and Elliptio complanata were collected from the nearshore zones. Samples were analyzed for As and Hg by neutron activation in 1984, and by neutron activation and atomic absorption spectrometry, respectively, in 1985. Some of the mussels were dissected into four organs (mantle, gills, viscera and muscle) which were analyzed separately.

Chironomids and oligochaetes, which burrow in the sediment, accumulated significantly higher concentrations of As (up to 287 ug/g dry weight) and Hg (up to 6.4 ug/g) than Chaoborus sp., which spend much of their time in the water column. Concentrations of As and Hg in chironomids were highly correlated with concentrations in the sediment (r=0.75 and 0.96, respectively; n=6), therefore we recommend chironomids as biomonitors for the deep zones of the lakes.

Snails accumulated higher concentrations of As (up to 350 ug/g), but less Hg than mussels. In mussels, As bioaccumulation did not differ between species and did not very with the size (dry weight) of the organism. However, some very small specimens from the most contaminated site accumulated unusually high concentrations of As (up to 117 ug/g) as compared with the rest of the population (22-42 ug/g). Higher As concentrations in the viscera (which accounts for over 50% of the body weight) in smaller mussels may account for this.

Average tissue concentrations of Hg were 3 to 4 times higher in E. complanata (2.32 - 2.65 ug/g) than A. implicata (.56 - .97 ug/g) from the same locations. Concentrations in A. implicata from three lakes varied by only a factor of 3 (.5 - 1.5 ug/g) despite a wide range in sizes (0.04 - 3.45 g) and ages (4 - 9 years) of the specimens. This suggests that A. implicata is capable of regulating Hg at the environmental levels to which it is exposed in the Shubenacadie Lakes system. In contrast, Hg concentrations in E. complanata from the same three lakes varied by a factor of 17 (.59 - 9.95 ug/g) and much of the variability was due to the size of th organism. Tissue concentrations increased almost exponentially with increasing dry weight over a weight range of 1.0 - 3.0 g, suggesting that this species continually accumuates Hg as it grows. The specimens ranged in age from 5 - 17 years. Mercury concentrations were highest in the mantle and viscera, intermediate in the gills and lowest in the muscle in E. complanata. Concentration in all organs increased with increasing body weight. Mercury concentrations did not differ among the organs in A. implicata.

Based on their bioaccumulation potentials, we recommend the snail, Helisoma sp., as a promising biomonitor for As in nearshore areas, and the mussel, E. complanata , for mercury. These findings will be useful for monitoring the ecological

consequences of further disturbances in the Shubenacadie Lakes and similar environments contaminated with arsenic and mercury.

Keywords: Arsenic, mercury, bioaccumulation, benthic invertebrates, mussels.

Les lacs en amont de la rivière Shubenacadie près de Halifax (Nouvelle-Ecosse) ont été contaminés par de l'arsenic (As) et du mercure (Hg) à la suite de l'exploitation de mines d'or près de la municipalité de Waverley. Afin de déterminer l'ampleur de la contamination de l'écosystème et de sélectionner les organismes les plus utiles pour une surveillance biologique, on a étudié des invertébrés benthiques prélevés dans cinq de ces lacs en 1984 et 1985. Dans les zones profondes des lacs, on a prélevé des spécimens de *Chaoborus* sp., de *Chironomus* sp. et d'oligochètes et dans les zones littorales, on a récolté des gastéropodes *Helisoma* sp. et des moules *Anodonta implicata* et *Elliptio complanata.* On a analysé la teneur des spécimens en As et Hg par activation neutronique en 1984, et par activation neutronique et spectrométrie par absorption atomique en 1985. On a disséqué les moules pour en analyser séparément quatre organs (manteau, branchies, masse vicérale et muscles).

On a découvert que les chironomides et les oligochètes, qui vivent enfouis dans les sédiments, accumulaient des quantités considérablement plus élevées d'As (jusqu'à 287 ug/g de poids sec) et de Hg (jusqu'à 6, 4 ug/g) que les *Chaoborus* sp., qui passent la plus grande partie de leur vie dans la tranche d'eau. Les concentrations de As et Hg dans les chironomides étaient très comparables aux concentrations dans les sédiments (r = 0,75 et 0,96 respectivement; n = 6); nous recommandons donc d'utiliser les chironomides comme indicateur de surveillance biologique dans les zones profondes des lacs.

Les gastéropodes accumulaient des concentrations plus élevées de As (jusqu'à 350 ug/g), mais moins de Hg que les moules. La bioaccumulation de As dans les moules ne variait pas en fonction des espèces ni de la grosseur (poids sec) des organismes. On a cependant découvert que les très petits spécimens provenant des sites les plus contaminés avaient accumulé des concentrations anormalement élevées de As (jusqu'à 117 ug/g) en comparaison du reste de la population (11-42 ug/g). Cela pourrait s'expliquer par le fait que les plus petites moules accumulent des concentrations plus élevées de As dans leur masse viscéral (qui constitue plus de 50 p. 100 du poids corporel).

Les concentrations moyennes de Hg dans les tissus de *E. complanata* (2, 32-2, 65 ug/g) étaient de 3 à 4 fois plus élevées que dans les tissus de *A. implicata* (0, 56-0, 97 ug/g) prélevés au même endroit. En dépit de la grande variété de poids (0,04 à 3,45 g) et d'âges (4 à 9 ans) des spécimens de *A. implicata* provenant de trois différents lacs, les concentrations dans les échantillons ne variaient que par un facteur de 3 environ (0,5-1,5 ug/g). Cela laisse croire que les spécimens de cette espèce sont en mesure de régulariser jusqu'à un certain point l'absorption de mercure en fonction des niveaux auxquels ils sont exposés dans l'environnement du système lacustre Shubenacadie. Par contre, les concentrations de Hg dans *E. complanata* provenant des trois mêmes lacs variaient par un facteur de 17 (0,59 à 9,95 ug/g) et cet écart était dû en grande partie aux différences de taille entre les organismes. A partir d'une échelle de poids de 1,0 à 3,0 g, ls concentations tissulaires augmentaient de façon presque exponentielle avec l'augmentation de poids sec, ce qui suggère que cette espèce accumule du Hg d'une façon progressive à mesure qu'elle croit. L'âge des spécimens variait de 5 à 17 ans. Chez *E. complanata* . les concentration de mercure étaient plus élevées dans le manteau et la masse viscérale, moyennes dans les branchies et plus faibles dans les muscles. Les concentrations de mercure dans tous les organes augmentaient en fonction du poids corporel. Chez *A. implcata* , les concentrations de mercure ne variaient pas d'un organisme à l'autre.

Si on se base sur leur pouvoir de bioaccumulation, on peut recommander d'utiliser le gastéropode *Helisoma* sp. comme indicateur de surveillance biologique du As et la moule *E. complanata* pour le mercure. Ces découvertes seront utiles pour surveiller les conséquences écologiques de contaminations ultérieures à l'arsenic et au mercure dans les lacs du système Shubenacadie et d'environnements semblables.

Mots clés: arsenic, mercure, bioaccumulation, invertébrés benthiques, moules.

THE MITIGATING EFFECT OF CALCIUM ON ALUMINUM TOXICITY IN TWO SPECIES OF FRESHWATER FISH,

W.A.C. Gibson, Trent University, Peterborough, Ontario

Lethality tests with common shiners (*Notropis cornutus*) and rainbow trout (*Salmo gairdneri*) were run to determine the effect of calcium on aluminun toxicity. A diluter system was used to maintain tank concentrations of 1, 4, and 10 mg/L of calcium and 0, 50, 100 and 150 µg/L of aluminum at pH 4.8 and 5.1. Fish were exposed as eyed-eggs (just prior to hatch) and exposure continued until swim-up. Results indicate that aluminum is clearly toxic, but that this toxicity appears to be mitigated by calcium, especially at pH 4.8. Neutron activation data indicate that these treatments produced significant changes in the levels of aluminum, calcium, sodium, chloride and magnesium in the embryos of rainbow trout, but there were no changes in potassium concentrations in the test fish.

Des tests de létalité furent effectués chez le mené à nageoires rouges (*Notropis cornutus*) et la truite arc-en-ciel (*Salmo gairdneri*) afin de déterminer l'effet du calcium sur la toxicité à l'aluminum. Un système de dilution fut utilisé pour maintenir des concentrations dans les réservoirs à 1,4 et 10 mg/l de calcium et 0, 50, 100 et 150 µg/l d'aluminum à un pH de 4.8 et de 5.1. Les poissons ont été exposés juste avant l'éclosion, alors que les yeux étaient visibles dans les oeufs. Ils ont été exposés jusqu'au temps de l'éclosion. Les résultats indiquent que l'aluminum est certainement toxique, mais que cette toxicité semble être atténuée par le calcium, spécialement à un pH de 4.8. Les résultats obtenus grâce à l'activation de neutrons indiquent que ces traitements ont produit des changements significatifs dans les niveaux d'aluminum de calcium, de sodium, de chlore et de magnésium chez les embryons de la truite arc-en-ciel. Par contre, il n'y avait pas de changements dans les concentrations de potassium dans les poissons testés.

Paper: THE MITIGATING EFFECT OF CALCIUM ON ALUMINIUM TOXICITY IN TWO SPECIES OF FRESHWATER FISH

Speaker: W. A. C. Gibson, Trent University, Peterborough, Canada

J. Howard McCormick, U.S. Environmental Research Laboratory, Duluth, U.S.A.: Can you give me some information on the gas bladder of the rainbow trout at low pH?

W. A. C. Gibson: This was not studied.

AVOIDANCE-PREFERENCE REACTIONS OF RAINBOW TROUT (*Salmo gairdneri*) AFTER PROLONGED EXPOSURE TO CHROMIUM (VI),

I. Anestis and R.J. Neufeld, Faculty of Engineering, McGill University, 817 Sherbrooke St. West, Montreal, Quebec, Canada H3A 2K6

Avoidance-preference reactions were studied in rainbow trout (*Salmo gairdneri*) pre-exposed for 7-20 weeks to potassium dichromate solutions ($K_2Cr_2O_7$) ranging from 0.01 to 3.0 mg/l as Cr(VI). Experiments were performed in a hydraulic channel 9.15 m long by 30 cm wide, partly divided along its length and at a flow depth of 30 cm, combining steep and shallow gradient characteristics. An avoidance threshold value of 0.028 mg/l was determined for a population which had not been previously exposed to chromium while avoidance thresholds for pre-exposed fish increase linearly with the level of pre-exposure. Pre-exposed fish exhibited lower avoidance reactions compared to the nonexposed population. Avoidance reactions decreased with increasing level of pre-exposure. Fish exposed to test concentrations matching their pre-exposure level clearly preferred this same concentration over any adjacent lower or higher test concentration. After 7 days of acclimation in clear water fish previously exposed at 0.01-0.8 mg/l Cr(VI), behaved similarly to the nonexposed population, indicating functional recovery of chemoreceptive capacity, while fish pre-exposed beyond the 0.8 mg/l Cr level did not recover fully within the same 7 day acclimation period. The 0.8 mg/l Cr (VI) level is proposed as a critical pre-exposure level for short term recovery of normal chemoreceptive capacity. Times of pre-exposure within the range used for the study had no influence on avoidance reactions.

Les réactions d'évitement-préférence ont été étudiées chez la truite arc-en-ciel qui avait été pré-exposée de 7-20 semaines à des solutions de dichromate de potassium (K_2 Cr_2O_7) variant de 0.01 à 3.0 mg/L comme Cr.(VI). Les expériences ont été réalisées dans un canal hydraulique de 9.5 m de long par 30 cm de large partiellement divisé sur la longueur et à une profondeur d'écoulement de 30 cm, combinant ainsi les caractéristiques de gradient prononcé et peu profond. Un seuil d'évitement d'une valeur de 0.028 mg/L fut déterminé pour une population n'ayant pas été préalablement exposée au chrome tandis que les valeurs de seuil d'évitement des poissons ayant été pré-exposés augmentent de manière linéaire suivant le niveau de pré-exposition. Les poissons pré-exposés démontrent des réactions d'évitement plus basses que la population non-exposée. Les réactions d'évitement diminuent avec une augmentation du taux de pré-exposition. Les poissons exposés à des concentrations-tests équivalentes au niveau de leur pré-exposition, préferaient clairement cette même concentration plutôt que n'importe laquelle des concentrations-tests adjacentes de niveau plus bas ou plus haut. Après 7 jours d'acclimatation à l'eau claire, les poissons qui avaient été précédemment exposés à 0.01-0.8 mg/L Cr(VI) se comportent comme ceux de la population non-exposée indiquant ainsi la récupération fonctionnelle de la capacité chémoréceptive, tandis que les poissons pré-exposés à un niveau de plus de 0.8 mg/L Cr(VI) n'ont pas récupérés complètement pendant la même période d'acclimatation de 7 jours. Le niveau de 0.8 mg/L Cr(VI) est proposé comme le niveau de pré-exposition critique pour la récupération de la capacité chémoréceptive normale à court terme. Les durées de temps de pré-exposition aux concentrations utilisées, n'ont pas d'influence sur les réactions d'évitement.

Paper: AVOIDANCE-PREFERENCE REACTIONS OF RAINBOW TROUT (*Salmo gairdneri*) AFTER PROLONGED EXPOSURE TO CHROMIUM (VI)

Speaker: I. Anestis, McGill University, Montreal, Canada

C. Morry, D. F. O., Moncton: Is the avoidance threshold of 0.028 mg/l half that of WSEPA & EPS standard for plating industry or their water quality criteria?

I. Anestis: Water quality criteria

AN ANALYSIS OF LESIONS AND CONTAMINANTS FOUND IN A POPULATION OF BELUGA WHALE *(Delphinapterus leucas)* from the St. Lawrence Estuary, Québec, P. Béland (1), D. Martineau (2), R. Massé (3) and C. Desjardins (4)

A total of 58 whales from a resident population have been found dead over the last 4 years along the St. Lawrence; 44 animals were sampled for contaminants and 15 fresher carcasses were autopsied. This is the first study on whales where the same animals were sampled for contaminants and submitted to pathological examinations. Major contaminants were organochlorines (PCBs, DDT, Mirex) and poly-aromatic hydrocarbons (benzo (a) pyrenes). Organochlorine levels reported here are higher than previously reported for cetaceans, with the exception of harbour porpoises from the Bay of Fundy in the 1970's. Organochlorine profiling shows DDE as the most abundant compound in all tissues examined. The major PCB components were tetra- to heptachlorobiphenyl, thus including several persistent and toxic congeners. Four of the observed lesion had never been described before in cetaceans or odontocetes, while the incidence of tumors and of gastric lesions was much higher than among other samples of cetaceans. Three of the most contaminated animals had more than one severe lesion. Adipose tissue PCB levels were higher than in several species of mammals where hormonal and reproductive dysfunctions have been noted. BaP exposure levels were comparable to those in laboratory animals exposed under controlled conditions to carcinogenic doses. There is evidence that reprodutive rates in th population are lower than in Arctic populations, while the recorded deaths indicate excess mortality at an early age. These findings constitute strong indications that the low population numbers are attributable to contamination.

Un total de 58 baleines d'une population résidente ont été retrouvées mortes le long du Saint-Laurent au cours des 4 dernières années. Quarante-quatre animaux ont été échantillonnés pour mesurer les contaminants et les 15 carcasses les plus fraîches ont été autopsiées. C'est la première fois chez les cétacés que les mêmes animaux sont soumis en même temps à des études toxicologiques et pathologiques. Les contaminants principaux étaient des composés organochlorés (BPC, DDT, Mirex) et des hydrocarbures aromatiques polycycliques (benzo (a) pyrènes). Les taux de composés organochlorés retrouvés sont les plus élevés à ce jour chez les cétacés, à l'exception de marsouins communs de la Baie de Fundy durant les années 1970. Le profil des composés organochlorés identifie le DDE comme le composé le plus abondant dans tous les tissus. Les principaux isomères de BPC sont les tétra- jusqu'à heptachlorobihényles, incluant ainsi plusieurs composés persistants et toxiques. Quatre des lésions observées n'avaient jamais été rapportées auparavant chez les cétacés ou les odontocètes, tandis que l'incidence de tumeurs et de lésions gastriques était beaucoup plus élevées que chez d'autres échantillons de cétacés. Trois des animaux les plus contaminés avaient plusieurs lésions graves. Les niveaux de BPC dans le tissu adipeux sont plus élevés que chez plusieurs autres espèces de mammifères chez lesquels de dysfonctions hormonales et reproductives ont été notées. L'exposition au BaP est comparable à celle d'animaux de laboratoire exposées sous conditions contrôlées à des doses cancérigènes. Des données indiquent que le taux de reproduction dans cette population est inférieur à celui des

populations arctiques, tandis que les morts enregistrées montrent un excès de mortalité à un âge précoce. Ces faits constituent une forte indication que la faibesse des effectifs de la population est attribuable la contamination.

(1) Centre de Recherche en Ecologie des Pêches, Rimouski

(2) Faculté de Médecine vétérinaire, Université de Montréal, St. Hyacinthe

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Session 6. AQUATIC TOXICITY TO FISH.

TOXICITE AQUATIQUE AFFECTANT LES POISSONS.

ZITKO, V., and N.Y. KHAN. Chairpersons

PRIORITY SITE SELECTION FOR DEGRADED AREAS BASED ON MICROBIAL AND TOXICANT SCREENING TESTS. 1. LAKE ONTARIO, CANADIAN INSHORE AREAS,

B.J. Dutka, K. Walsh, K.K. Kwan, A. El-Shaarawi, D.L. Liu and K. Thompson, National Water Research Institute, P.O. Box 5050, Burlington, Ontario, Canada L7R 4A6

The goal of this ongoing series of studies is to indentify degraded or degrading water bodies by using a variety of microbiological, biochemical and bioassay tests. These tests, E. coli, coliphage, coprostanol, cholesterol, dehydrogenase activity, genotoxicity and Microtox tests, are being evaluated as potential candidates for a battery of test procedures which can be used nationally to prioritize water bodies and sediments for remedial action or further investigations. The battery approach should make it possible to establish "hot spots", areas for immediate concern which were not previously suspected due to inappropriate or one-dimensional testing procedures. Tests which can be performed on refrigerated or frozen samples, 24-96 hours after collection, will be given priority when the selection of the final recommended battery of microbiological, biochemical and bioassay tests are made. In this study, 51 inshore sampling sites were selected along with north shore of Lake Ontario from Kingston to the Niagara River. An arbitrary rating scheme was developed for the results obtained from the various tests. Based on this point rating scheme, there were four areas where sediment and water data were both in the top ten point totals: STP outfall, Humber area; mouth of Mimico Creek; mouth of Credit; and near Belleville STP outfall, Bay of Quinte.

Keywords: E. coli, coliphage, coprostanol, dehydrogenase activity, genotoxicity and Microtox test

Le but de ces études est d'identifier les eaux dégradées ou en train de subir la dégradation en utilisant une variété de tests, microbiologiques, biochimiques et de bioessais. Ces tests tel, E. coli, coliphage, coprostanol, cholesterol, activité du déhydrogénase, génotoxicité, et le test Microtox, sont en train d'être évalués comme moyens potentiels capables d'identifier, au niveau du pays, les eaux et les sédiments qui nécessiteraient des mesures correctives et une surveillance plus prononcée. Cette série de tests pourraient permettre d'identifier des "endroits chauds", nécessitant une attention immédiate. Ces endroits n'auraient pu être identifiés par le passé parce que le seul test employé était inadéquat. Les tests pouvant se faire, sur des échantillons réfrigérés ou congelés, de 24 à 96 heures après la cueillette, seront considérés en priorité lorsque le choix des tests microbiologiques, biochimiques et bioessais se fera. Lors de cette étude 51, stations d'échantillonnage furent établies le long de la grève nord du Lac Ontario de Kingston à Niagara River. Un processus de classification arbitraire fut mis au point pour les résultats obtenus grâce aux différents tests. En ce basant sur cette classification, il y avait 4 endroits où les données pour les sédiments et l'eau étaient en tête de liste: Retombées de STP, région de Humber; embouchure de Mimico Creek; embouchure de Credit; Retombée de STP près de Belleville, Baie de Quinte.

Paper: COMPARISON OF SEDIMENT TOXICANT EXTRACTION PROCEDURES FOR MICROTOX TOXICITY SCREENING TESTS

Speaker: K. K. Kwan, Canada Centre for Inland Waters, Burlington, Canada

P. Ross, Univ. of Illinois/Illinois Natural Hist. Surv., USA: Is there any difference in the variances of measurements obtained with the two extraction procedures.

K. K. Kwan: Have not looked at that.

NOVEL TRENDS FOR AQUATIC TOXICITY TESTING AT THE DNA LEVEL,

(1) R. Van Coillie, (1) C. Blaise, (2) F. Denizeau and (3) J.C. Dol

While various contaminants entering aquatic ecosystems can cause insult to DNA molecules, their genotoxic mode of action is often unclear. In this respect, agression mechanisms can be quite different and take on the various types outlined below:

(i) Flagrant genotoxicity:	
Mutagenicity	Ames test
DNA strand damage and/or carcinogenic initiation	DNA repair test
Chromosomal aberrations	Microscopic caryotyping
Teratogenicity	
(II) Insidious genotoxicity:	
Carcinogenic promotion	Epigenetic effects on cells leading to a state of malignancy
Delayed toxicity induction	DNA promotors synthesis inhibition

Growing interest for all of these tests invokes the need to specify their limitations and meanings.

Bien que divers produits toxiques contaminant des milieux aquatiques soient reconnus comme des agents pouvant affecter l'ADN et subséquemment le génome, leurs mécanismes génotoxiques s'avèrent mal connus. Bien que très différents du point de vue biomoléculaire, ceux-ci peuvent être répartis selon les groupes suivants auxquels correspondent des bioessais de détection:

(i) Génotoxicité flagrante	
-Mutagénicité	Test d'Ames et autres tests de mutabilité
-Altération de l'ADN	Test de réparation de l'ADN
-Abbération chromosomique	Examen microscopique du caryotype
-Tératogénicité	Fréquence tératogène chez des souches particulières
(ii) Génotoxicité insidieuse	
-Cancérogénicité:	
Initiation	Effet endogénique avec réponse biochimique
Promotion	Effet épigénique menant à un développement tumoral
-Induction de toxicité	Tests d'inhibition retardée de la synthèse de promoteurs au niveau ADN

L'intérêt croissant pour ces différents tests et la confusion à leur sujet demandent qu'on en spécifie leurs limitations et significations.

CHEMICAL CARCINOGENESIS STUDIES WITH FISH, C.D. Metcalfe, Trent University, Peterborough, ONT

The discovery of high incidences of tumors among feral fish populations in the Great Lakes, and other areas of North America has stimulated concern over the possible association of these diseases with waterborne carcinogens. Two research projects are in progress which examine this putative association. An *in vivo* assay has been developed for nuclear aberrations (micronuclei) in the erythrocytes of fish species (mudminnows, brown bullhead). It is anticipated that this technique will be useful for identifying fish populations exposed *in situ* to aquatic carcinogens/clastogens. The second project examines the carcinogenic effects of extracts from contaminated Lake Ontario sediments using the trout embryo carcinogenesis assay. These studies will indicate whether aquatic contaminants are tumor initiators and/or tumor promotors in a fish carcinogenesis model.

La découverte des hautes fréquences de tumeurs parmie les populations de poissons des Grands Lacs et d'autres régions de l'Amérique du Nord, a provoqué des inquiétudes à savoir que ces maladies pourraient être associées avec des carcinogènes portés par l'eau. Deux projets de recherches sont en cours afin d'examiner cette association possible. Un essai *in vitro* a été développé pour décaler des aberrations nucléaires (micronoyaux) dans le erythrocytes de poissons. On s'attend à ce que cette technique soit utilisable pour identifier les populations de poissons qui ont été exposées *in situ* aux carcinogènes/clastogènes aquatiques. Le deuxième projet examine les effets carcinogéniques d'extraits de sédiments contaminés du Lac Ontario en utilisant l'essai de carcinogénèse chez l'embryon de la truite. Ces études nous permettront d'identifier si les contaminants aquatiques sont des initiateurs de tumeurs ou/et des promoteurs de tumeurs dans un modèle de carcinogénèse chez le poisson.

Paper: CHEMICAL CARCINOGENESIS STUDIES WITH FISH

Speaker: C. D. Metcalfe, Trent University, Peterborough, Ontario

N. Hutchinson, Dorset Research Centre, Min. Environment, Ont. Have you considered using a fast-developing fish, such as flagfish, zebrafish or fathead minnow in order to shorten your tests from 1 to 2 years for rainbow trout? Is the problem with those species related to egg size?

C. D. Metcalfe: It is easy to use the eggs of rainbow trout. The physical injection injures the small eggs of those species and so we do not yet have a suitable technique. Other workers have used eggs of medaka and they immersed them in the test chemical but the membrane prevents the easy uptake.

Claude Thellan, Env. Quebec: Following the embryo injection of contaminants did you notice any teratogenic effects after hatching?

C. D. Metcalfe: Not with sediment extracts. But some of these effects were observed with petroleum effluents.

Rachel Léger, Centre Marin, Shippagan, NB: Would you not think that a bottom fish like the brown bullhead be more apt to contact carcinogenesis problem than a swimming fish like rainbow trout?

C. D. Metcalfe: Probably. The rainbow trout still develops tumors following carcinogenic injections.

Kelly Munkittrick, University of Waterloo: Have you considered including trout liver enzyme preparations in addition to Vat S9 as part of the screening process?

C. D. Metcalfe: That has been suggested in the past and it may be possible to compare the carcinogenic potential of brown bullhead liver extracts from polluted and non-polluted sites. A great advantage to this type of system is its flexibility.

POLYCHLORINATED BIPHENYL COMPOSITION OF LAKE ONTARIO
SALMONIDS, A.J. Niimi and B.G. Oliver. Dept. Fisheries
and Oceans, Environment Canada, Burlington, Ont. L7R 4A6

The congeneric and isomeric chlorinated biphenyl composition were examined in lake, brown, rainbow trout, and coho salmon collected from Lake Ontario. Total PCB content in whole fish averaged 10.0 ppm in lake trout, 2.4 ppm in brown trout, 1.4 and 5.6 ppm in small (1.1 kg) and large (3.5 kg) rainbow trout, and 2.0 and 4.6 ppm in small (1.2 kg) and large (3.3) coho salmon. A comparable analyses of muscle samples indicated total PCB levels of 1.1, 3.9, 0.3, 2.1, 0.8, and 2.3 ppm for the respective species.

An examination of the isomeric composition demonstrated a highly consistent relationship among the species when the presence of each isomer was expressed as a percentage of the total PCB composition. The 2,4,5,2',4',5'-hexachlorobiphenyl was the most common representing about 10% of the total PCB content in each species even though concentrations of this isomer ranged from 130 to 1080 ppb among the species examined. Eight other pentachloro- and hexachloro- isomers each represented about 4 to 6% of total PCBs. Most of the other 44 to 58 isomers that were identified in whole fish each represented less than 1% of total PCB content. A similar response in relative composition was demonstrated in muscle although the number of isomers identified declined to 28 to 52 among the species examined.

La composition en congénères et isomères de biphenyl chlorés fut examinée chez la truite de lac, la truite brune, la truite arc-en-ciel et le saumon coho du Lac Ontario. Le contenu total en PCB des poissons entiers est en moyenne de 10,0 ppm chez la truite de lac, de 2,4 ppm chez la truite brune, de 1,5 et de 5,6 ppm chez les petites (1,1 kg) et les grandes (3,5 kg) truites arc-en-ciel, de 2,0 et de 4,6 ppm chez les petits (1,2 kg) et les grands (3,3 kg) saumons coho. Des analyses similaires d'échantillons de muscles indiquent un contenu moyen en PCB de 1,1, 3,9, 0,3, 2,1, 0,8 et 2,3 ppm respectivement pour les diverses espèces.

L'examen de la composition isomérique indique une relation systématique pour les diverses espèces lorsque la présence de chaque isomère est exprimée en pourcentage du contenu total en PCB. Le 2, 4, 5, 2', 4', 5' - hexachlorobiphenyl était le plus abondant, représentant environ 10% du contenu total en PCB de chacune des espèces. Ceci s'applique même si la concentration de cet isomère varie de 130 à 1080 ppb selon les espèces. Huit autres pentachloro- et hexachloro- isomères représentaient chacun entre 4 et 6% des PCB totaux. La majorité des 44 autres des 58 isomères identifiés chez les poissons entiers représentaient chacun moins de 1% du contenu total en PCB. Dans le cas de l'analyse des muscles, le nombre d'isomères identifiés déclina à 58 jusqu'à 28 selon les espèces examinées.

THE USE OF BRAIN MONOAMINE METABOLISM AS AN INDICATOR OF TOXICANT IMPACT ON FISH, B.E. Hickie, D.A. Holdway, B.D. Sloley, R.G.H. Downer and D.G. Dixon, Dept. of Biology, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1

One requirement for environment health assessment is the development of rapid biochemical indicators of toxicant impacts. The metabolism of biogenic monoamines (Dopamine, Norepinephrine, Epinephrine, Serotonin) has been used successfully in assessing toxicant impact to higher vertebrates, but has received little attention in aquatic toxicology. Since these compounds are important components of homeostatic mechanisms, toxicant effects on their metabolism can severely affect an organism's viability. We are presently active in assessing the potential of using amine profiles in aquatic toxicology. Information on the methodology for the sampling and determination of biogenic amines in fish will be presented. The effects of methoxychlor exposure on the brain amine profiles of American flagfish (Jordanella floridae , Goode and Bean) will be presented in relation to effects on behavior, development and reproductive success.

Keywords: biogenic monoamines, brain, methoxychlor, behavior, development, reproduction, flagfish

Le développement d'indicateurs biochimiques rapides pour déterminer les impacts d'agents toxiques est une exigence dans l'évaluation de la santé environnementale. Le métabolisme de monoamines biogéniques (Dopamine, Norépinéphrine, Epinéphrine, Sérotonine) a été utilisé avec succès dans la détermination de l'impact d'agents toxiques sur les vertébrés supérieurs mais a reçu peu d'attention dans le domaine de la toxicologie aquatique. Vu que ces composés sont d'importantes composantes des mécanismes homéostasiques, les effets d'agents toxiques sur leur métabolisme peuvent gravement affecter la viabilité d'un organisme. Présentement, nous évaluons activement le potentiel de profils d'amines en toxicologie aquatique. Les effets d'exposition au méthoxychlor sur les profils d'amines du cerveau de Jordanella floridae seront présentés par rapport aux effets sur le comportement, le développement et le succès de reproduction.

Paper: THE USE OF BRAIN MONOAMINE METABOLISM AS AN INDICATOR OF TOXICANT IMPACT ON FISH

Speaker: B. E. Hickie , D. A. Holdway, D. B. Sloley, R. G. H. Downer and D. G. Dixon, University of Waterloo, Waterloo Canada.

King Ming Chan, MSRL, Memorial University, St. John's: What is the gradient of acetonitrile you applied to your reverse phase HPLC column in order to separate the monoamines?

B. E. Hickie: Not known.

I. Anestis, McGill University: Was the ten days pre-exposure to pentachlorophenol chosen using a particular rational or was it decided randomly? Were fish tested after a different length of time exposure, for example 20 days?

B. E. Hickie: It was based on the LC50 values we had. We did not check for the influence of time of pre-exposure on the results.

Session 7. FISH EPIDEMIOLOGY AND POLLUTION EFFECTS ON FISH.

EPIDEMIOLOGIE DES POISSONS ET EFFETS DE LA POLLUTION SUR LES POISSONS.

WESTLAKE, G., and CHRISTIAN BLAISE. Chairpersons

INDUCTION OF HEPATIC METALLOTHIONE IN MESSENGER RNA IN THE WINTER FLOUNDER (*PSUEDOPLEURONECTES AMERICANUS*) AFTER CADMIUM CHLORIDE INJECTION, K. M. Chan, W. S. Davidson, and G. L. Fletcher, Marine Sciences Research Laboratory and Department of Biochemistry, Memorial University of Newfoundland, St. John's, Newfoundland A1C 5S7

In order to understand the bioregulation of metallothionein synthesis and to study the role of metallothione in metal detoxification in fish, a molecular approach has been chosen. The isolation of an enriched fraction of metallothionein messenger RNA (mRNA) and its subsequent cloning should provide use with a specific, accurate and sensitive method for following metallothionein induction and quantifying metallothionein mRNA levels in winter flounder tissues. To achieve this goal, the first step was to identify whether any metallothionein mRNA could be found in the total poly A plus mRNA from winter flounder following cadmium injection.

Total mRNA was purified from liver of winter flounder treated with a series of intraperitoneal injections of cadmium chloride. Analysis of the poly A plus mRNA directed cell free translation products by polyacarylamide gel electrophoresis under native and denaturing conditions showed that hepatic mRNA from cadmium injected flounder translated to yield metallothionein. Metallotionein was not detected in the translation products of mRNA isolated from liver of saline treated (control) flounder. mRNA from both cadmium and saline (control) treated liver produced a similar amount of 35 -cysteine incorporated protein in an *in vitro* translation system. Several other low molecular weight cysteine labelled proteins were also found in the cell free translation products of mRNA from cadmium and saline treated liver.

Further analysis of the mRNA using 5-30% sucrose density gradient centrifugation revealed that metallothionein mRNA was enriched in the 8-10S fractions. Complementary DNA (cDNA) was prepared from the 9S fraction labelled with p=dATP and applied to a 7M urea 6% acrylamide DNA sequencing gel. Following autoradiography, the cDNA was found to fall in the range from 500 to 600 nucleotides. Mammalian metallothionein cDNA also falls within this size range.

In summary, the conclusion that metallothionein was a cell free translation product directed by winter flounder poly A plus mRNA was based on the following criteria: a) the metallothionein cell free translation product was only produced by RNA from cadmium treated liver samples; b) the carboxymethylated derivative comigrated with similarly treated winter flounder metallothionein on both native and denaturing (SDS) polyacrylamide gel electrophoresis systems; c) the peak in cell free translation activity on sucrose density gradients corresponded to a sedimentation coefficient of 9S which is the size of metallothionein mRNA isolated from mammals.

Keywords: metallothionein, messenger RNA, cDNA, cadmium, detoxification.

De l'ARN messager total (ARNm) fut purifié à partir de foie de carrelet d'hiver grâce à une série d'injection intrapéritonéale de $CdCl_2$. Le ARNm fut traduit dans un système *in vitro* pour libérer de la métallothionéine. Plusieurs autres protéines de faible poids moléculaire et marquées à la cystéine furent obtenues de poissons traités *in vitro* au cadmium ou avec

une solution saine. Des analyses approfondies de l'ARNm par ultra centrifugation en gradient de sucrose a démontré que l'ARNm à métallothionéine se trouvait en plus grande quantité dans les fractions de 8-10S. La synthèse de cADN à partir de cet ARNm à métallothionéine sera un outil utile dans l'analyse qualitative permettant de définir à quel taux la synthèse du métallothionéine dans le poisson est sujettée à l'exposition au métal. Cet outil nous permettra de définir le rôle de la métallothionéine dans la détoxification métalique du poisson.

PENTACHLOROPHENOL: A REVIEW OF ITS EFFECTS AT THE LEVEL OF THE INDIVIDUAL JUVENILE LARGEMOUTH BASS,

P.H. Johansen, Department of Biology, Queen's University, Kingston, Ontario, Canada K7L 3N6

This study was designed to investigate the effects of PCP and several physiological and behavioural aspects of early life stage bass.

The 96h LC50 for bass fry up to 28 days olds was 285 µg/L; this declined to 159 µg/L for fry 49-84 days old which indicates a loss of tolerance. Growth and food conversion efficiency was reduced by PCP concentrations in excess of 25 µg/L. The response to PCP was also affected by ration level. Exposure of fish (guppies) to PCP concentration at 50% of the 96h LC50, or higher, increased their vulnerability to predation. Exposure of bass fry to a range of PCP concentrations during their first eight weeks of life results in reduced feeding modal action patterns (MAP) and rates of prey capture at concentrations above 50 µg/L. Bass fry exposed to 50 µg/L PCP for four weeks experienced a significant reduction in body lipid. These results will be discussed in relation to their implication on populations and with regard to the US-EPA water criterion level for PCP of 48 µg/L.

Cette étude a été conçue dans le but d'investiguer les effets du PCP et les aspects physiologiques et comportementaux de la vie débutant de l'Achigan.

Le LC50 de 96h pour des alevins d'Achigan âgés de 28 jours était de 285 µg/L; ce résultat est diminué à 159 µg/L pour les alevins âgés de 49 à 84 jours, ce qui indique une perte de tolérance. L'efficacité de la conversion de nourriture et la croissance sont réduites par des concentrations de PCP excédant 25 ug/L. Cette réponse au PCP est également affectée par le niveau du régime alimentaire. L'exposition d'alevins d'Achigan à des concentrations variées de PCP pendant les huit premières semaines de vie, avait pour résultat la réduction du patron d'action modale (PAM) de nutrition et la vitesse de capture de proies à des concentrations au-dessus de 50 µg/L. Des alevins d'Achigan exposés à des concentrations de PCP de 50 µg/L pendant quatre semaines ont eu des réductions des lipides du corps. Ces résultats seront discutés en relation à leur implication pour les populations et en regard du de critère d'eau US-EPA pour le PCP de 48 µg/L.

Paper: PENTACHLOROPHENOL: A REVIEW OF ITS EFFECTS AT THE LEVEL OF THE INDIVIDUAL JUVENILE LARGEMOUTH BASS

Speaker: P. H. Johansen, Queen's University, Kingston, Canada

Gary Westlake, Ministry of the Environment, Ontario: Do you think the variation sensitivity from a different age fish relates to periods where the fish are naturally mobilizing lipids?

P. H. Johansen: Can I guess? No, these young bass, the yoke is fully absorbed within two or three days after they have become free swimming. I mean fully absorbed it's within the body by the time they become free swimming. It's fully absorbed that would be a good source for lipids, there after they are feeding exogenously in all manner on zooplankton what the composition of zooplankton would be in terms of lipid and carbohydrate and precisely what they can metabolize more readily,whether it's lipid or carbohydrate, I don't know yet. I would look at it but talking about a little creature 7mm long and they're only available for 6 - 8 weeks in a year where we are, so I haven't even thought of doing useful bio-chemistry on them. I'll welcome biochemists looking at them.

PAPILLOMATOSIS AND CHOLANGIOLAR NEOPLASIA IN FISH FROM HAMILTON HARBOUR, LAKE ONTARIO, I.R. Smith , H.W. Ferguson, D.A. Rokosh and M.A. Hayes, Dept. of Pathology, University of Guelph, Guelph, Ont. N1G 2W1

Cholangiolar neoplasms were found in 2.7% (n=147) of white suckers *(Catostomus commersoni)* and 2.9% (n=170) of brown bullheads *(Ictalurus nebulosus)* from Hamilton harbour. Control suckers (n=44) from an agricultural basin, and bullheads (n=51) from Long Point Bay, Lake Erie, has no such neoplasms. Bile duct hyperplasia was present in 6% of Hamilton suckers, 15% of Hamilton bullheads, 14% of control suckers, and 21% of control bullheads. hepatocellular hyperplasia in suckers (9%) and bullheads (4%) from Hamilton was more prevalent than in control fish (0%). Focal populations of altered hepatocytes were observed only in bullhead livers, particularly in those from Hamilton (26%, 7% in control). Epidermal papillomatosis on 59% of Hamilton suckers and 55% of Hamilton bullheads was more common than control (25 and 15% respectively). Epidermal and hepatic lesions were not observed in carp *(Cyprinus carpio)*, although genetically abnormal hybrids with *goldfish* from both sites had gonadoblastomas. Chronic exposure to physical irritants or chemical toxicants may be involved in the pathogenesis of both skin and hepatic lesions in the Hamilton fish. Pollution of Hamilton harbour may be in part responsable, however viruses and parasites are also possible etiolgical agents.

Keywords: pollution, fish, tumours, skin, liver, viruses, parasites

Des néoplasmes cholangiolaires furent décelés chez le Catostome noir *(C. commersoni)* à raison de 2.7% (n=147) et chez la barbotte brune *(I. nebulosus)* à raison de 2.9% (n=170) en provenance du hâvre d'Hamilton. Des catostomes contrôles (n=44) en provenance de bassin agricole ainsi que des barbottes (n=51) de Long Point Bay sur le Lac Erié ne démontraient pas de tels néoplasmes. Une hyperplasie du canal biliaire fut découverte chez 6% des catostomes d'Hamilton, 15% des barbottes d'Hamilton, 14% des catostomes contrôles et 21% des barbottes contrôles. L'hyperplasie hépatocellulaire était plus commune chez les catostomes (9%) et les barbottes (4%) en provenance d'Hamilton que chez les poissons contrôles (0%). Des foyers d'hépatocytes altérés furent décelés dans le foie des barbottes, plus particulièrement chez celles en provenance d'Hamilton (26%; 7% chez les poissons contrôles). Une papillomatose épidermique s'est révélée être plus commune chez les catostomes d'Hamilton (59%) et chez les barbottes d'Hamilton (55%) que chez les poissons contrôles (25% et 15% respectivement). Nous n'avons pas décelé de lésions épidermiques ou hépatiques chez la carpe *(C. carpio)*. Cependant des hybrides génétiquement anormaux de *C. auratus* en provenance des deux sites avaient des gonadoblastomes. La pathogénèse des lésions épidermiques et hépatiques chez les poissons d'Hamilton pourrait être due à une exposition chronique à des irritants physiques ou des produits chimiques toxiques. La pollution des eaux du hâvre d'Hamilton est peut-être en partie responsable mais il ne faut pas négliger les virus et parasites qui sont des agents possibles.

Paper: PAPILLOMATOSIS AND CHOLANGIOLAR NEOPLASIS IN FISH FROM HAMILTON HARBOUR, LAKE ONTARIO

Speaker: I. R. Smith, University of Guelph, Guelph, Ontario

Gary Westlake, Ministry of the Environment, Ontario
Is this a typical site? Are there other sites that you are aware of that have these sort of rates?

I. R. Smith: In Canada, North America or the Great Lakes?

G. Westlake: Which ever you like.

I. R. Smith: There are 6 sites in North America that have tumor rates similar to this or higher. Ballpark figures we are in the middle of the road of Hamilton Harbour. There are a couple of locations on both sides of American coast where the rates are higher. There are other inland locations where the rates are similar to this. It's not uncommon in fact it's at the point now that if you look hard enough you will find them, in these industrial excluded locations. Now one thing I did not cover was that these fish that are getting the tumors are old and they're 8 to 9 years old, most of them, and it doesn't take much over a life span to increase these tumor rates. Some of the sites of United States get the same tumor frequency. Tumors take only 2 to 3 years to develop, which perhaps indicates there is a lot higher concentration across. Counting from the last 2 years it's gone up from 3 to 6 number of sites and it'll keep going up.

Henry Regier, University of Toronto: Given the work, on this problem in fish of Great Lakes are data now sufficient to draw maps of incidence, etc.

I. R. Smith: For the bullheads and the white suckers we're getting an excellent data base, yes. We don't know anything about the other species yet. The white suckers are pretty well studied and we are getting a good idea of what's going on. One problem we don't know is that we can determine the incidence but we don't know where the fish are getting the carcinogens from. If you look at the Hamilton Harbour site, we think there is probably a population of fish that stays in the Harbour most of the time. But these fish we think it's probably nothing for them to travel 20 or 30 miles in the summer between spawning and coming back to the river. So if you've got a fish that he might be in Toronto this year and next year he might be in Port Hope, which is 70 or 80 miles down the coast. We can determine the tumor incidence but we have to study where the tumors come from before we draw those lines.

Henry Regier: Is there any sort of diagram or map or aid of these incidence of this to co-ordinate?

I. R. Smith: There is no co-ordinate effort right now to summarize the tumor rates of the Great Lakes. No.

P. H. Johansen, Queen's University: With respect to the information which you mentioned from the States as two years. Could this be a temperature related phenomena since that release of fish from the States-from the Southern U. S.-where mean annual temperature is not at warm growing season much longer.

I. R. Smith: In general, no, most of the fish that have been shown growing tumors it's on the Pacific, Atlantic, and North West. In North East it's very cold water, long lived species generally and one factor is all the fish that are getting the tumors are bottom fishes, tend to be longer lived species. Colder waters on the bottom and the temperature we don't think it's too important. It might be. But as far as the wild fish go, there is no evidence, not a lab says there is a difference, that's a whole different story, temperature has a profound influence in the lab, not to production, promotion, progression, that type of thing.

THE EFFECTS OF TOXICANT MIXTURES ON DNA, RNA, AND PROTEIN CONTENT OF FATHEAD MINNOWS

J.L.Parrott , R.M.Wilson, K.A.Payne, A.Laing and J.B.Sprague, Zoology Department, University of Guelph, Guelph, Ontario, Canada. N1G 2W1

Water quality criteria are based on individual chemicals, but in the real world aquatic pollutants are seldom found singly. This discrepancy can perhaps be accounted for by the lack of scientific data on the toxicity of mixtures. Decades could be spent testing the vast number of chemical combinations with conventional thirty-day growth tests, or life-cycle studies on fish. Such sublethal assays must be performed since lethal tests cannot be depended upon to show the patterns of joint action, mechanisms of effect often being different at the sublethal level. The development of quick, accurate sublethal assays would prove invaluable in the breaching of a subject this large.

We adapted a technique from the literature, of using the DNA, RNA, and protein content of day-old fathead minnows exposed for only 96 hours, as accurate predictors of sublethal effects of toxicants (M.G.Barron and I.R.Adelman, 1984. Can. J. Fish. Aquat. Sci., 41:141-150).

The metals tested were copper and zinc, each at five concentrations (including zero). This yielded a total of twenty-five treatments, derived from all possible combinations of these toxicant levels. After the exposure, an ethidium bromide fluorimetric technique was used to quantify the nucleic acids. Protein content was determined by the Lowry method. These variables reflect the development and growth potential of the larvae exposed to toxicant mixtures.

Response surface diagrams represent the plane of effects of the toxicant mixtures (Figure 1). The DNA response surface is a flat plane, indicating an "additive" effect of copper and zinc on DNA content. The RNA surface is curved, suggesting that the toxicants have "less than additive" effects on this parameter. Protein was found to have a similar mound-like response surface. The response surface plot for dry weight could not be constructed due to great variability. This emphasizes the efficiency of using DNA, RNA, and protein as sensitive and relatively precise indicators of sublethal effects. To document such effects by measurement of weight would apparently require a longer exposure (several weeks, according to Barron and Adelman).

The intersection of the upper 95% confidence plane (about the response surface) with the control value can be used to distinguish effects that are different from the control at the level of 95% confidence (Figure 2). The dividing line was more-or-less straight, even though the RNA response surface was curved. With this approximation of linearity, we may interpret the thresholds of effect as being simply additive for copper and zinc acting together. Thus, the values of concern for protecting environments follow the concentration addition model.

From the figures it is evident that very small concentrations of copper and zinc (68 ug/L of Cu alone, 210 ug/L of Zn alone, and proportional fractions of mixtures) adversely affect the DNA, RNA, and protein content, significantly reducing it from the control value. Thus, a four-day exposure appears sufficient to predict whether the minnow's growth is affected by the mixed toxicants (Barron and Adelman, 1984).

It is intended to test a pair of organic chemicals and a pair of insecticides, then proceed to between-category investigation. It is not expected that one clear-cut formula for additive action will be derived. However,the patterns of interaction shown by response surfaces may provide insight which we hope will assist in modifying water quality criteria as necessary, to protect aquatic environments from mixtures of pollutants.

Keywords: mixture toxicity, sublethal, fathead minnow,
nucleic acids.

Un des plus grands problèmes envisagé par les toxicologistes aquatiques de nos jours est celui de la toxicité de mélanges toxiques. Il y a beaucoup de données publiées sur les critères de qualité d'eau pour de produits toxiques utilisés individuellement, mais il existe très peu d'information quand plus d'un produit chimique est impliqué. Puisque dans ce monde, on retrouve rarement des produits toxiques seuls, une étude sur l'action des mélanges serait d'un grand intérêt. En utilisant des larves de poisson qui viennent juste d'éclore, nous avons testé 3 paires de produits toxiques: des métaux, des substances organiques narcotisantes et des pesticides. Des effets subléthaux furent examinés puisque les patrons déterminés par des tests léthaux pouvaient ne pas s'appliquer à doses subléthales après une exposition de 4 jours. L'ADN, l'ANR, les protéines et le poids sec des larves furent aussi étudiés. La réponse la plus sensible fut observée pour l'ARN, révélant des effets subléthaux qui montraient un caractère d'additivité ressemblant à ceux de produits toxiques pairés ayant une action semblable. L'utilisation accrue de tests précis nous permettra de faire des études détaillées de mélanges toxiques dans le futur.

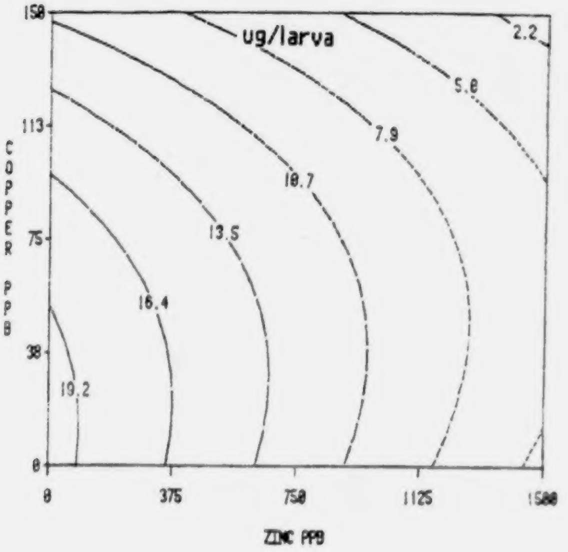

FIGURE 1

RESPONSE SURFACE PLOT FOR COPPER-ZINC MIXTURE STUDY. THE RESPONSE IS RNA IN ug/LARVA.

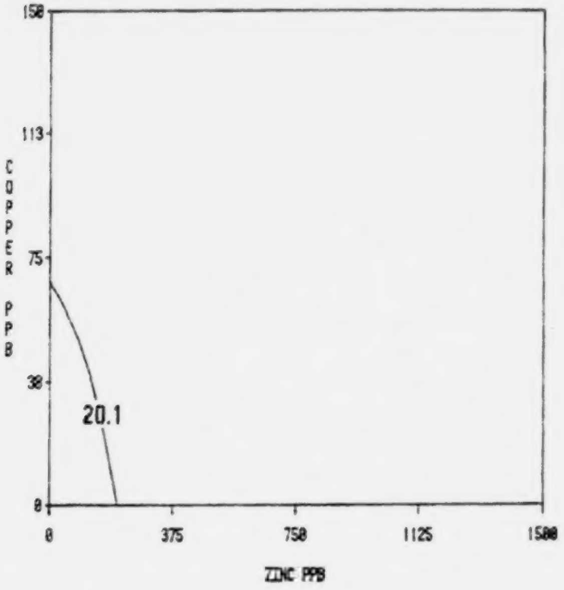

FIGURE 2

INTERSECTION OF THE UPPER 95% CONFIDENCE SURFACE AND A HORIZONTAL PLANE THROUGH THE INTERCEPT.
THE RESPONSE IS RNA IN ug/LARVA.

Paper: THE EFFECTS OF TOXICANT MIXTURES ON DNA, RNA AND PROTEIN CONTENT OF FATHEAD MINNOWS

Speaker: J. L. Parrott, Dept. of Zoology, University of Guelph, Guelph, Ont. N1G 2W1

C. Blaise, Env. Canada, SPE, Longueuil: I was wondering how practical this type of functional is like with DNA, RNA and protein. How practical could it be, would you say, out in the field , of the functional type of effect of parameters in assessing environmental health on a routine basis. Are these type tests efficient, are they lengthy, did you do them a lot?

J. L. Parrott: They are quite short tests actually, and I think as far as using this in the field , it is something that could be done perhaps by comparing the clean or dirty waters. Collecting eggs and keeping them three or four days in the water that they were in and you bring them back to the laboratory keeping them in the water and then do exactly as we've done and measure the DNA, RNA and protein and compare the results between the two. It is not a lengthy procedure. It only takes four days. The results are available and very quick.

C. Blaise: So you feel that it has field application.

J. L. Parrott: Yes, I think so.

DEVELOPMENT OF MULTIRESISTANCE PATTERNS IN THE BACTERIAL FLORA OF TROUT FOLLOWING AN ANTIBIOTIC THERAPY.

R. Léger * and R. Lallier. Dept. of Patho. and Microbiol. Fac. of Vet. Med. Univ. of Montreal, *Marine Centre, Shippagan, N. B.

This study aim to evaluate the effects of SxT (sulfamethoxazole - trimethoprim) and R-05 (sulfadimethoxine - ormetoprim) on the intestinal flora of speckled trout. A first part *in vivo* is performed, with twenty-five gram speckled trout divided into a control, a SxT and a R-05 group. The treated groups received 50 mg/kg of fish per day of SxT or R-05. Three trout from each group are sacrificed every day during the five day treatment and every five days post treatment. The number of bacteria per gram of intestinal content is evaluated and the dominant colonies are identified to the genus or when possible to the species.

As second part *in vitro* follows. Dominant colonies from each group and each day are evaluated for their antibiotic resistance patterns. The antibiogram of each strain is determined by a modified Bauer et al. (1966) method. The Mueller Hinton culture media are complemented with lysed horse blood and incubated at 20°C and 30°C. Different sensitive or resistant bacterial strains are selected in order to verify the possibility of resistance transfer by bacterial conjugation.

The analysis of the results show a control group giving a bacterial flora composed almost exclusively of Gram-negative rods, sensitive to the antibiotics tested except for ampicillin.

Pellets medicated with SxT produce a drastic drop in the Gram negative population while the effect is a lot less important with the R-05 coated pellets. Moreover, at the end of the treatments, after the bacterial flora is back to it's initial number, the flora from the SxT group shows different multi-resistance patterns whereas the R-05 group shows a flora sensitive to all the antibiotics tested except for ampicillin.

The bacterial conjugation succeeded by the transfer of tetracycline resistance between different strains of *Aeromonas* and to *E. coli* ,and by the transfer of the triple sulfa resistance between *A. salmonicida* strains and from *A. hydrophila* to *A. salmonicida.*

Further to these resistance transfers, it is to be feared that the uncontrolled antibiotherapy in fish ponds and hatcheries, could become a source of resistance causing therapeutic difficulties and even become a public health hazard.

Cette étude a pour but d'évaluer l'effet du SxT (sulfaméthoxazole - triméthoprime) et du R-05 (sulfadiméthoxine - ormétoprime) sur la flore intestinale des truites mouchetées. Une première partie *in vivo* est effectuée avec des truites mouchetées d'environ vingt-cinq grammes divisées en trois groupes: le contrôle, le SxT et le groupe R-05. Les groupes traités reçoivent 50 mg/kg de poisson par jour de SxT ou de R-05. Trois truites de chacun des groupes sont sacrifiées tous les jours durant le traitement de 5 jours et aux cinq jours suivant le traitement. Le nombre de bactéries par gramme de contenu intestinal est évalué et les colonies dominantes sont identifiées au genre, ou lorsque possible à l'espèce.

Une étude *in vitro* fait suite durant laquelle les souches dominantes de chacun des groupes et chacun des jours sont

évaluées pour leur patrons de résistance aux antibiotiques. Un antibiogramme de ces souches est déterminé d'après une modification de la méthode de Bauer et coll., 1966. Les milieux de culture Mueller-Hinton sont additionnées de sang de cheval lysé et incubés à 20°C et 30°C. Certaines des souches bactériennes résistantes et sensibles sont sélectionnés afin de vérifier la possiblité de transfert de résistance par conjugaison bactérienne.

L'analyse des résultats démontre un groupe contrôle ayant une flore bactérienne composée presqu'exclusivement de bâtonnets Gram-négatifs, sensibles aux antibiotiques vérifiées, saut pour l'ampicilline.

La moulée médicamentée de SxT provoque une baisse drastique dans la population Gram-négative alors que l'effet est beaucoup moins important avec la moulée complémentée de R-05. De plus, une fois les traitements terminés et la flore bactérienne rétablie en nombre, la flore du groupe SxT démontre différents patrons de multirésistance alors que le groupe R-05 démontre une flore sensible à tous les antibiotiques vérifiées sauf pour l'ampicilline.

La conjugaison bactérienne est réussie par le transfert de résistance à la tétracycline entre différentes souches d' Aeromonas et à E. coli , et par le transfert de la résistance au triple sulfa entre des souches d' A. salmonicida , et d' A. hydrophila à A. salmonicida. Suite à ces transferts de résistances, il est à craindre que l'antibiothérapie incontrolée chez les poissons, pourrait devenir une source de résistance causant des difficultés thérapeutiques, et pourrait même devenir un danger pour la santé publique.

Paper: DEVELOPMENT OF MULTIRESISTANCE PATTERNS IN THE BACTERIAL FLORA OF TROUT FOLLOWING AN ANTIBIOTIC THERAPY

Speaker: R. Léger, Dept. of Pathology and Microbiology, Faculty of Veterinary Medicine, Université de Montréal, Montréal, Canada

C. Blaise: Can the antibiotic resistance pattern verified *in vitro* effectively take place in receiving waters or effluents?

R. Léger: It is felt that bacterial conjugation (intra-and inter-specific) could take place. This has not really been verified, though.

Session 8. SEDIMENT TOXICITY TESTING

DETERMINATION DE LA TOXICITE DES SEDIMENTS

CLAIR, T.A. Chairman

SEDIMENT TOXICITY TESTS AND THEIR RELEVANCE IN ASSESSING THE QUALITY OF AQUATIC ECOSYSTEMS - A MEETING OF IDEAS, T.A. Clair, Water Quality Branch, Atlantic Region, Environment Canada, P.O. Box 861, Moncton, N.B., Canada E1C 8N6

Sediment quality surveys often produce data which show positive contaminant values. Little information exists which can be used to explain the ecological significance of these data, however. The purpose of this session is to bring together sediment toxicologists and users of toxicological data, to discover what information each field can provide the other, and what data or conceptual gaps need to be filled in order to bring more relevance to the work of both groups. At the end of the presentations and discussions, participants should be in a position to answer a number of questions relevant to this burgeoning field: i) what methods are currently available for the toxicological testing of sediments, and what are their limitations; ii) what new developments are forthcoming, and what will their impacts be on how we perceive toxicological testing; and iii) is the work currently being done in the monitoring and toxicology of sediments relevant to the assessment of the health of aquatic ecosystems.

Keywords: sediment, data, users, ecosystem health, monitoring

L'analyse qualitative des sédiments démontrent souvent des résultats de contamination positive. Il existe, cependant, peu d'information permettant d'expliquer l'importance écologique de ces résultats. Le but de cette session est de favoriser le dialogue entre les toxicologistes sédimentaires et les utilisateurs de données toxicologiques. Ceci nous permettra de voir quelles informations chaque groupe peut fournir à l'autre et d'identifier les données manquantes afin que le travail de chaque groupe ait plus de valeurs. Les présentations et les discussions terminées, les participants devraient être en mesure de répondre à un certain nombre de questions se rapportant à cette discipline:
i) Quelles sont les méthodes actuellement disponibles pour analyse toxicologique des sédiments et quelles sont leurs limites?
ii) Quels nouveaux développements sont en voie de se réaliser et quels seront leurs impacts sur le testing toxicologique?
iii) Le travail qui se fait actuellement permet-il de déterminer l'état de santé des écosystèmes aquatiques?

TOXICITY TESTING OF SEDIMENTS - PROBLEMS, TRENDS AND SOLUTIONS,

M.R. Samoiloff, Senior Scientist, Bioquest International, Inc.,
204-2989 Pembina Highway, Winnipeg, Manitoba R3T 2H5

There are presently available sensitive, cost-effective methods for evaluating the toxic properties of environmental samples, including sediments. These will be reviewed. The application of these methods must be viewed critically, with clear *a priori* scientific and management objectives. The types of toxic effects, the types of potentially impacted organisms, and the natural bioavailability of detected toxicants must be considered. Biological testing must be performed within the framework of a decision-matrix in which the data obtained can be used for managementon regulatory decisions. The development of such decision matrices, the scientific basis of them, and the possibility of developing detoxification strategies will be presented.

Keywords: bioassay, sediments, toxicology, environmental management, monitoring

Il existe présentement quelques méthodes sensibles, efficaces mais quelque peu couteuses, disponibles afin d'évaluer les propriétés toxiques d'échantillons environnementaux incluant les sédiments. Elles seront passées en revue. L'application de ces méthodes doit être examinée de façon critique, considérant en priorité les objectifs scientifiques et administratifs. les types d'effets toxiques, les types d'organismes potentiellement susceptibles à ces effets, et la disponibilité biologique naturelle des éléments toxiques trouvés devront être considérés. Les analyses biologiques doivent être accomplies dans le cadre d'une matrice de décision dans laquelle l'information obtenue peut être utilisée pour prendre des décisions administratives et pour établir une règlementation. Le développement de telles matrices de décisions , leur base scientifique et la possibilité de développer des statégies de désintoxification sontprésentées.

Paper: TOXICITY TESTING OF SEDIMENTS - PROBLEMS, TRENDS AND SOLUTIONS

Speaker: M. R. Samoiloff, Bioquest International Inc., Winnipeg, Canada

Suzanne Roussel, EPS, Env. Canada, St. John's: Have you considered utilizing the ultrasonic agitation to liberate the WSF in sediment?

M. R. Samoiloff: Yes, various methods are being used and sonification is one of them. But this method is not preferable in all types of material. Publications are available on this subject.

SEDIMENT BIOASSAY AND BIOASSESSMENT: AN AGENCY PERSPECTIVE, Edwin D. Ongley, National Water Research Institute, Environment Canada, Box 5050, Burlington, Ont. L7R 4A6

Conventional monitoring for ambient water chemistry for protection and assessment of aquatic resources, has generally assumed that a relationship exists between observed chemistry and "health" of the aquatic resource. Except in cases of gross pollution, this assumption is not usually warranted. This situation is no less true for toxic chemical assessment in aquatic systems. The presence of toxic chemicals raises new interpretive challenges for public agencies insofar as the public expects information on toxic effects on th aquatic resource and on potential risk to public health.

Toxic chemical sensing has required that agencies expand surveillance to include sedimentary and biological substrates. Either, however, raise important questions concerning the objectives of the agency, the particular analytical or investigative approaches adopted, and the real "information content" of the results for assessment purposes.

In this paper, I explore some of the limitations of the sedimentary and biological approaches to aquatic toxicological assessment. An alternative approach, using water and sediment bioassay, has widespread practical application for assessing potential for toxic risk in aquatic systems. This approach provides inexpensive information which permits public agencies to make objective judgements about the potential for site contamination and intersite comparison.

L'évaluation conventionnelle de la chimie du milieu aqueux en vue de l'étude et de la protection des ressources aquatiques a généralement supposé qu'une relation existe entre la chimie observée et la "santé" de la ressource aquatique. Excepté dans les cas de pollution extrême, cette idée n'est pas ordinairement justifiée. Cette situation est aussi vraie pour l'évaluation de la toxicité chimique dans les systèmes aquatiques. La présence de produits chimiques toxiques apporte des nouveaux défis d'interprétation pour les agences public car le publique veut connaître les effets toxiques sur la ressource aquatique et le risque potentiel à la santé publique.

La détection des produits chimiques toxiques a nécessité que les agences augmentent leur surveillance, incluant celles des substrats sédimentaires et biologiques. Cependant, les deux soulèvent des quetions importantes concernant les objectifs de l'agence, l'approche analytique adoptée, et la vraie "valeur en information" des résultats pour fins d'évaluation.

Dans cet article, quelques contraintes des approches sédimentaires et biologiques à l'évaluation de la toxicité aquatique sont explorées. Une approche alternative, à l'aide de bioessais de l'eau et de l'air, a des utilités pratiques diverses pour l'évaluation du risque potentiel de la toxicité dans les systèmes aquatiques. Cette approche founit de l'information peu coûteuse qui permet aux agences publiques de faire des jugements d'une façon objective concernant le potentiel de contamination d'un endroit et la comparaison de différents endroits.

THE INTERPRETATION OF SEDIMENT DATA IN SUPPORT OF OCEAN DUMPING PERMIT APPLICATIONS AND THE ROLE OF OCEAN DUMPING RELATED RESEARCH IN IMPACT ASSESSMENT AND DECISION MAKING - AN OVERVIEW, Alan R. McIver and Koh Leung Tay, Marine Environmental Protection Branch, Conservation and Protection, Environment Canada, Atlantic Region

The day to day management of ocean dumping is based upon the application of established criteria for assessing the acceptability of material for ocean disposal. The validity of these criteria in terms of their being representative of actual toxicity in the environment, and the decisions based upon them require verification by *in situ* monitoring of actual dumping operations.

A brief description of the ocean dumping permit process is given. Examples of the considerable ocean dumping research carried out in support of or to evaluate ocean dumping projects are given covering physical, chemical and biological parameters.

Future directions for ocean dumping related research are discussed.

L'aménagement journalier de déversements marins est basé sur l'application de critères établis pour évaluer l'acceptabilité de produits déversés dans la mer. La validité de ces critères représentatifs de la toxicité actuelle de l'environnement, ainsi que les décisions basées sur ces critères exigent vérification au site même des déversements actuels.

Une brève description du processus d'obtention d'un permis de déversement océanique sera donnée. Des exemples de recherches importants portant sur les déversements marins seront présentéés. Ces recherches, exécutées pour évaluer des projets de déversements océaniques, couvrent les paramètres physiques, chimiques et biologiques.

Des orientations futures dans la recherche par rapport aux déversements marins seront discutées.

INTRODUCTION - OCEAN DUMPING CONTROL

Approximately 125 ocean dumping permit requests are reviewed and processed each year in the Atlantic Region. As much as 90% of these permits requested relate to the disposal of spoils originating from the dredging of harbours and channels from coastal ports. Acceptability for ocean disposal of these spoils is determined in part upon interpretation of the physical and chemical characteristics of these spoils based upon the analysis of samples which is required to accompany the applications. Additional evaluation by way of bioassays and analysis of biota tissues for contaminant loading is also used on occasion.

Ocean dumping is regulated in Canada under the Ocean Dumping Control Act (ODCA) which was promulgated in 1975 to ensure that Canada could honour her commitment to abide by the London Dumping Convention (1972) on the prevention of marine pollution by the dumping of wastes and other matters.

The administration of the ODCA is the responsibility of the Environmental Protection Service (EPS), Conservation and Protection, Environment Canada. EPS is assisted in the decision-making by Regional Ocean Dumping Advisory Committees (RODAC) which advise on the acceptability of materials proposed for dumping, the method and timing of disposal, the environmental and sociological implications of the disposal and the suitability of the dump site selected.

The ODCA prohibits the dumping of certain substances, or materials contaminated with them, which have been demonstrated to be toxic in the marine environment, unless they can be rapidly rendered harmless. Prohibited and restricted substances are listed in annexes to the ODCA and are referred to as Schedules I and II. The factors to be taken into account in granting permits are listed in Schedule III.

In general, these limits of acceptability lie close to what are considered to be the background levels. In order to adequately describe material to be dumped, representative samples must be taken. If the material is homogeneous, then a simple surface grab sample may suffice, but more often core samples taken in a grid pattern are required to define the lateral and vertical distribution of contaminants within the sediments.

PHYSICAL CHARACTERISTICS

The physical characteristics of the sediment are determined by sieve and pipette analysis for size distribution and are then graphed according to the Wentworth classification. The sediments can then be generally described in terms of percent rock, gravel, sand, silt and clay.

CHEMICAL CHARACTERISTICS

The objective of the chemical analysis is primarily to determine the presence and concentration of prohibited substances which may be present in the sediments to ensure that they do not exceed the nominal levels of acceptability. For example, if an application for a permit to dump 15,000 cubic meters of dredged spoils is received, five core samples might be required. Where appropriate, re-evaluation of samples and/or additional sampling may be required to identify whether pockets of contamination exist. Where such are found, an alternative dumping strategy is often adopted such as disposal behind a berm or a disposal on land with appropriate safeguards or special handling such as capping to rapidly render the contaminant harmless might be required if ocean dumping in the ocean is still considered a viable option. Although the process is designed to be as objective as possible, some degree of subjectivity and good judgement is required to interpret the data and recommend on appropriate terms and conditions and procedures.

OTHER FACTORS

In most cases, it is possible to grant an Ocean Dumping Permit; the Permit, however, will specifically detail the manner, timing and quantity of material which will be permitted to be dumped. Every effort is made to dispose of the spoils in a dump site which has similar physical and chemical characteristics. Generally, a dump site is chosen for its stability although, on occasion, sites are chosen for their dispersive circumstances related to its disposal.

Permits requested range in complexity depending upon the nature and volume of the sediments to be dumped. The disposal of relatively small quantities of sediments heavily contaminated with industrial wastes, such as may be found near ore loading wharves, dockyards, or active ports can often be best resolved by side-casting the material to an equally contaminated area. Although not resolving the contamination issue, this does at least minimize its spread while, at the same time, providing an economical solution to the dredging needs. Sometimes, however, major dredging in an active estuary is proposed, such as the dredging of the Miramichi during 1981-84 when in the order of four million cubic metres of dredged spoils were removed. Such an operation would require considerably more data than that available from simple sediment analysis such as a detailed biological and oceanographic characterization of both the dredge and dump site areas. Information on the biota, such as migration patterns of fish and lobsters, the location of shellfish beds and fish spawning grounds is essential if suitable timing and acceptable dump sites are to be located. Additional information such as the stability of selected dump sites and the behaviour of the bottom floc layer at the sediment/water interface is needed if right decisions regarding dredging and dumping patterns are to be made. Monitoring during critical periods of low oxygen level to ensure that dredging does not unduly lower the available oxygen and that disturbed sediment does not inhibit salmon migration is essential. In the case of the Miramichi, long-term (4-year) monitoring of heavy metal levels in shellfish tissues was a good indication of the trauma to and recovery of the biota.

In field studies, it is sometimes difficult to differentiate between impacts caused by physical and chemical factors. In a recent study to determine the effect of dredge spoils on juvenile lobster habitat, a quantity of fine sediment was dumped on a rocky substrate which was inhabited by juvenile lobsters (Hamet and Elner, 1983). Monitoring over the following two years indicated that a significant reduction in the number of juvenile crabs and lobsters occurred at the dump site and in the immediately adjacent area. Interpretation of the data indicates that considerable care should be taken to dump like material upon the substrate to minimize habitat change and loss of critical habitat and associated organisms.

BIOASSAYS AND IMPACT MONITORING

In evaluating permit requests, a tiered approach to assessment is employed to avoid unnecessary cost to the proponent. Often, the physical and chemical analysis of sediment samples will, together with other known facts about the area, be sufficient to establish permit terms and conditions. If, however, a question remains regarding the toxicity of the sediments and bioaccumulation of contaminants is suspected, a bioassay may be required.

Sampling and analysis of biota from the dredge site and the dump site also provides an indication of the long-term effect of the sediments upon the biota. Additional research and monitoring of the dump site after use provides direction for future decision-making. In the case of cadmium-contaminated dredge spoils disposal at the Public Wharf at Dalhousie Harbour, New Brunswick, biological testing was used to determine if cadmium in sediments was available to biota. In a bioaccumulation experiment conducted by Ray, McLeese and Peterson (1981), two sediment samples A and B were collected from Dalhousie Harbour and a thirty-day laboratory bioassay was carried out (Table 1). Cadmium was accumulated by polychaete (Nereis virens), and clam (Macoma balthica), from sediment sample B, but not from A! However, no cadmium was detected in the water overlying sample A while trace amounts were measured in water overlying sample B. It was hypothesized that cadmium entered the test animals from the water in a dissolved phase rather than by ingestion of sediments or other direct routes. Parallel static bioassay tests carried out respectively by MacLaren Marex Inc. (20-day bioassay, 1980) and the EPS Atlantic lab (30-day bioassay, Doe, K., 1981) confirmed that cadmium in the Dalhousie sediment was not biologically available. While the results of these experiments were not absolutely conclusive, they did provide assurance that the cadmium present in the Dalhousie Harbour spoils was not readily available to the biota under certain circumstances. A decision was made to contain the sediments in a bermed embayment. Subsequent monitoring of the decant water from these holding areas confirmed that cadmium was present only in trace amounts and within acceptable limits.

Confirmation of correct interpretation of data and monitoring of impacts is a necessary part of the review process. Whilst ideally all dumping projects should have follow-up monitoring, practically speaking, only a few can be thoroughly reviewed because of the high cost involved and because of the difficulty in determining effects in the marine environment due to limited visibility, depth and the other problems related to seafloor experimentation and investigation. However, within the existing constraints of manpower and resources, dump site monitoring of those sites considered to be most likely to have measurable impacts has been carried out by Environment Canada. In recent years, the use of a remote-controlled vehicle equipped with an underwater video camera has greatly increased the effectiveness of dump site assessment. Extrapolation of the results has provided insight for predicting possible impacts in similar situations and has aided in the process of determining the appropriate terms and conditions of Ocean Dumping Permits. The most extensive ocean dumping evaluation study carried out in Atlantic Canada to date is the four-year assessment and monitoring program conducted by Public Works Canada as a requirement of their Ocean Dumping Permit for the Miramichi Estuary dredging and dumping project. One of the impact assessment tools used was the analysis of tissue samples of representative benthic organisms. MacLaren Plansearch (1985), the contracted analysts, reported that cadmium in oyster (*Crassostrea virginica*), crab (*Cancer irroratus*), and clam (*Macoma balthica*) tissues were significantly elevated during the dredging operation. After the completion of the dredging project, there were indications that the concentration of cadmium accumulated in the tissues of these animals returned to the levels present before the start of the dredging project (Figure 1). However, there were insufficient quality-assurance controls accompanying the analyses to definitely relate the observed variations in cadmium levels to the dredging activity. Further refinement of methodology is needed in the area of biotesting both in laboratory and in the field to increase the validity of dredging and dumping monitoring projects.

Sediment	Copper		Zinc		Lead		Cadmium	
	A	B	A	B	A	B	A	B
N. virens	-	-	-	-	-	-	-	+
C. septemspinosa	-	-	-	-	+	+	-	-
M. balthica	+	+	-	+	+	+	-	+

TABLE 1: BIOACCUMULATION RESPONSE OF INVERTEBRATES TO METAL CONTENTS OF SEDIMENTS A AND B, AT 30 DAYS (Ray, McLeese and Peterson, 1981)

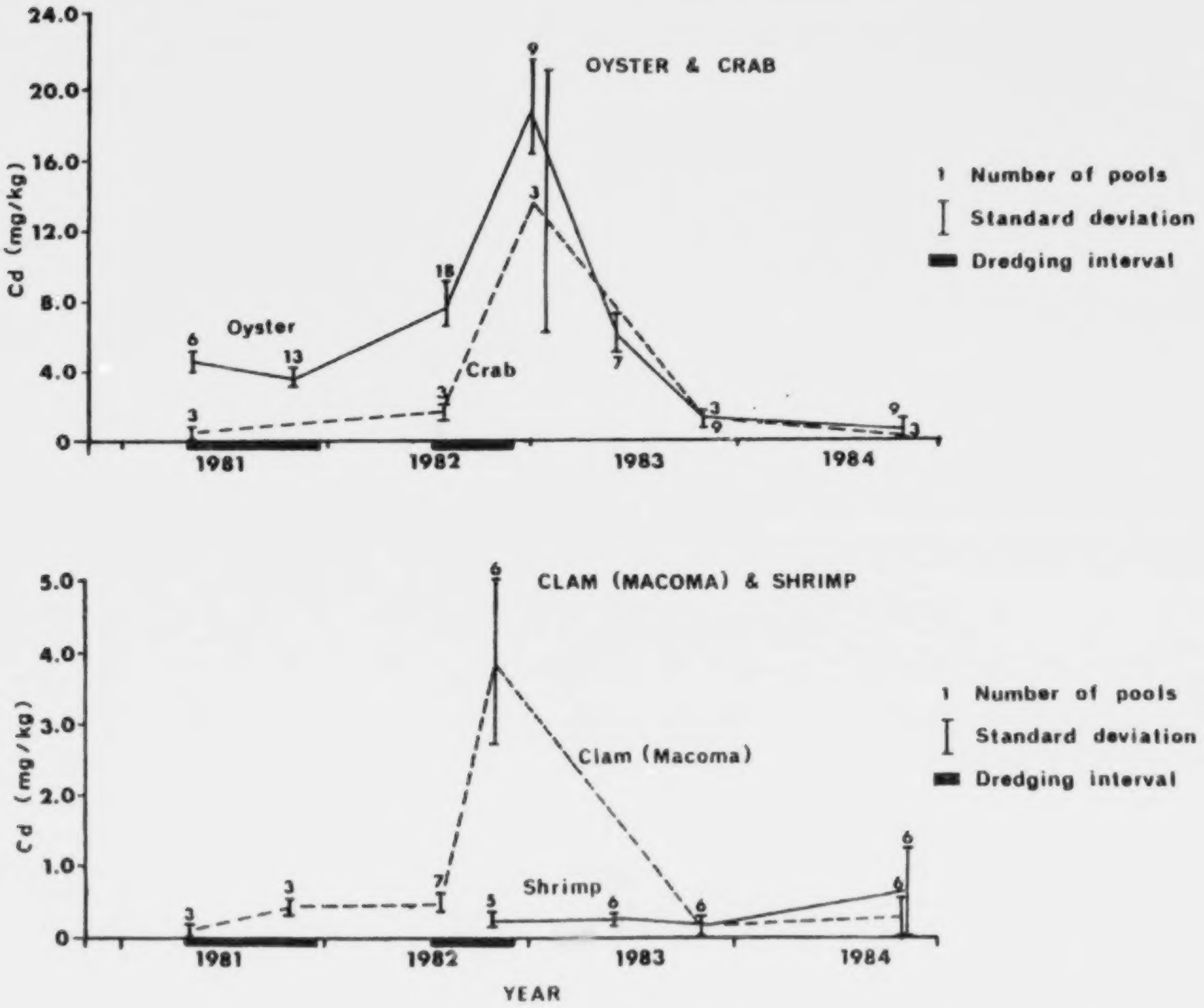

FIGURE 1. CADMIUM CONTAMINATION OF BIOTA (From MacLaren Plansearch 1985)

To assist in funding research related to ocean dumping, an Ocean Dumping Research Fund (ODCARF) was established in 1976. Each year, proposals are reviewed and evaluated on the basis of regional and national research priorities. Because of the need for an effective biological testing tool to evaluate acute or chronic toxicity, including the bioaccumulation of contaminants, biotesting has been one of the top priorities for the past three years. Since 1976, eighteen projects funded by ODCARF have been related to bioaccumulation studies or bioassay tests. One of the earliest was the evaluation of *Macoma balthica*, an infaunal sediment feeding mollusc common in this Region (Sharp, 1977). This has proved to be the most practical sediment assay organism identified to date used in a short-term (up to 30 days) lethality test in a static system. The search continues for other indicator species. At the 12th Annual Toxicity Workshop Andreé Chevrier and John Karau (1985) of Environment Canada reviewed the ecotoxicological tests and criteria that could be used for decision-making under the ODCA. Last year, a West Coast amphipod, *Rhepoxinius abronius*, was assessed and shows some promise. This year, it is hoped to demonstrate its practical application. Other approaches have also been proposed and are being evaluated. Ultimately, it is hoped that a reliable and truly representative test will be developed which will provide a rapid and accurate bioassay of marine sediment toxicity which closely parallels the conditions which exist in the field and we encourage others working in this area to help us in this search.

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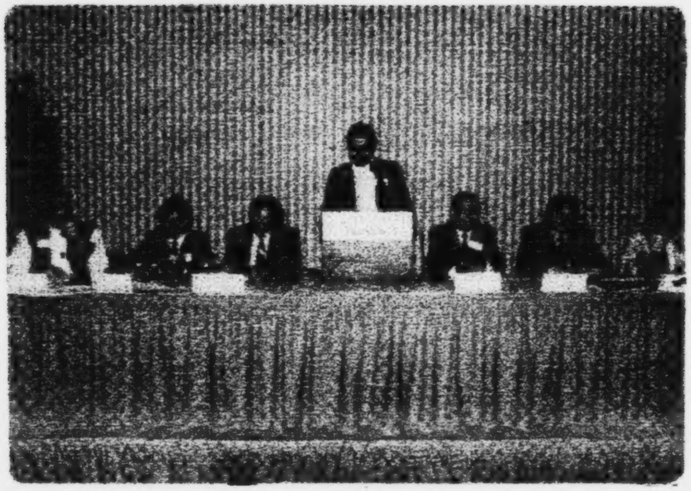
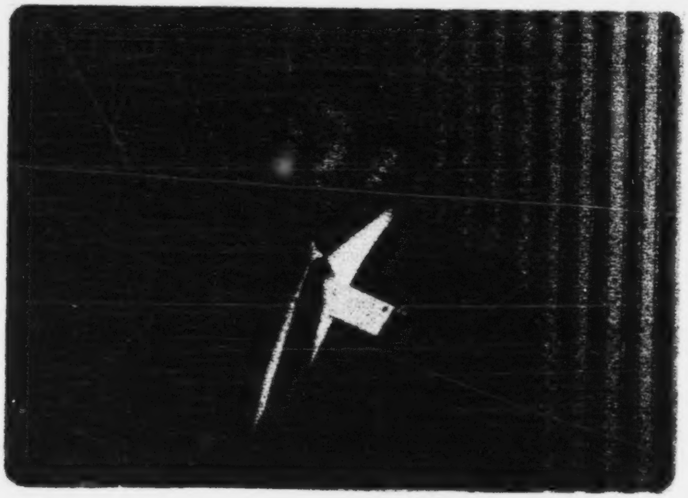


Session 9. AQUATIC TOXICITY AND THE MANAGEMENT OF MARINE ENVIRONMENTAL QUALITY - ITS ROLE, OPPORTUNITIES AND CONSTRAINTS

TOXICITE AQUATIQUE ET AMENAGEMENT DE L'ENVIRONNEMENT MARIN. IMPORTANCE, POSSIBILITES ET CONTRAINTES.

A panel discussion - Table ronde et discussions.

COTE, R. and P. WELLS. Chairpersons



WALDICHUK. M.

AQUATIC TOXICOLOGY AND THE MANAGEMENT OF MARINE ENVIRONMENTAL QUALITY - ITS ROLE, OPPORTUNITIES AND CONSTRAINTS. R. Côté, School of Resource and Environmental Studies, Dalhousie University, Halifax, Nova Scotia, and P. Wells, Environment Canada, Dartmouth, Nova Scotia, Chairpersons.

This session will explore the role of the science and practice of aquatic toxicology in the environmental management of estuarine and coastal waters. Aquatic toxicology, as a discipline, has been contributing to the identification and resolution of marine pollution problems for many years, and also has developed dramatically as a unique interdisciplinary science. A wide range of estuarine, coastal and offshore issues and problems require toxicological procedures. Applications of particular importance are predictive toxicity testing, the evaluation of mixtures, the assessment of cumulative impacts of substances and developments, surveillance and trend monitoring for biological effects, and the establishment of water quality guidelines and objectives as part of selected control strategies. The needs and applications are many, but aquatic toxicology is still developing and is fraught with new and uncalibrated techniques, and the uncertainty of predicting effects under natural conditions. What is needed is discussion and guidance on the questions and issues that aquatic toxicoloy should really be addressing, and the techniques that it should be developing in order to be a vital science in support of decision making for marine environmental protection, conservation an overall management. Such discussion and guidance is the objective of this workshop session, led by the main speaker and the panelists. It is hoped that key question might be asked so that the opportunities and constraints of marine aquatic toxicology might be identified, and its role in marine environmental management in Canada be strengthened.

Cette session discutera du rôle de la science et de la pratique de la toxicologie aquatique dans l'aménagement environnemental des estuaires et des eaux côtières.

En tant que discipline, la toxicologie aquatique, comme discipline, a contribué à l'identification et la résolution des problèmes de pollution marine pendant plusieurs années, et a aussi évolué comme une science interdisciplinaire particulière.

Des procédures toxicologiques sont requises dans un grand nombre de problèmes des milieux estuaires, côtiers et en haute mer.

Des applications d'importance particulière sont: échantillonages, possibilité de prédire la toxicité, l'évaluation de mélanges, l'évaluation des impacts cumulatifs des substances et des développements, surveillance et observation des tendances des effets biologiques, et l'établissement de directives sur la qualité de l'eau et les objectifs de stratégies contrôlés.

Les besoins et les applications sont nombreux, mais la toxicologie aquatique est encore en voie du développement et est remplie de techniques nouvelles non-calibrées et pour lesquelles la prédiction des effets sous des conditions naturelles est encore incertaine.

Nous avons besoin de discussions et de conseils sur les questions et les problèmes que la toxicologie aquatique doit traiter, ainsi que sur les techniques qui doivent être développées pour que celle-ci soit une science indispensable à la prise de décisions en ce qui concerne la protection de l'environnement marin, la conservation et de l'aménagement général du territoire.

De tels discussions et conseils sont l'objectif de cette session, dirigé par le conférencier et les invités. Il est souhaité que les questions-clés seront posées, afin que les possibilités et les contraintes de la toxicologie aquatique marine puissent être identifiés, et que son rôle dans l'aménagement environnemental marin au Canada soit fortifié.

SUMMARY OF THE PANEL DISCUSSION ON AQUATIC TOXICOLOGY AND THE MANAGEMENT OF MARINE ENVIRONMENTAL QUALITY - ITS ROLE, OPPORTUNITIES AND CONSTRAINTS, R. P. Côté and P. G. Wells.

This session explored the role of the science and practice of aquatic toxicology in the management of the quality of marine waters particularly addressing the relationship between laboratory and field approaches. The subject was considered by an ecologist - Dr. Patricia Lane, a regulator - Mr. Hugh Hall, the regulated - Mr. Fred Meth, a lawyer - Professor David VanderZwaag and a resource manager - Mr. John Loch. They provided their own perspectives while also commenting on the views expressed by our main speaker, Dr. Michael Waldichuk.

In his introductory remarks, R. Côté identified four questions for consideration by the panelists:

1. Should more effort go into standardization of methods and techniques than is the case now?

2. Is there an appropriate balance of research effort on predictive tools, assessment of mixtures and cumulative impacts and monitoring programs?

3. Is too much effort devoted to fish compared to other compartments of the marine environment?

4. From a legal point of view, are measurements of field impacts with all their variability more effective in influencing judges than very structured and quantifiable results of laboratory tests?

Aquatic toxicology, as a discipline, has been contributing to the identification and resolution of marine pollution problems for many years. As pointed out by Dr. Waldichuk the emphasis has been on bioassays first acute lethality testing but increasingly, sublethal testing of physiological, biochemical, morphological, genetic and behavioural effects. Multidisciplinary efforts are also underway to measure ecological effects at the population and community levels.

In his paper, Dr. Waldichuk described some of these initiatives by the Intergovernmental Oceanographic Commission, the International Council for the Exploration of the Sea and the Scientific Group of the London Dumping Convention to define the tests needed to answer specific questions dealing with management issues facing the marine environment. However, he also noted that field verification or monitoring would be necessary because of our inability to extrapolate from laboratory data and to assess cumulative effects of a variety of wastes. Depending on the types of questions that are asked, a suite of tests and techniques will have to be used. There is some hope that a few measurements, eg. scope for growth of mussels, may be more useful as indicators. He concluded, however, that aquatic toxicologists will have to concentrate effors on four phases: Identification of a change in space and time, quantification of the degree of change, causation, and consequences of the changes. It is by satisfying these phases that toxicology will play an effective role in th management of marine environmental quality.

While expressing some concern about continued reliance on standard toxicity tests and on LC50's in light of confounding factors which limit their usefulness in management, J. Loch argued that we have to continue using the best available information and advice. He recommended that continued efforts must be devoted to standardization of techniques and that more emphasis should be placed on biological effects monitoring. Unfortunately, we are still in a position of having to demonstate to politicians, judges and even to research managers that toxic effects on a few fish have negative implications on stocks and populations. "We must pursue ecological effects studies to properly and fully demonstrate the effects of contaminants."

In his presentation, H. Hall stated that "One of the biggest constraints to the use of aquatic toxicology in the preservation and enhancement of marine environmental quality is the difficulty in moving from measured effects on individuals or on conditions in the environment to fair, rational and understandable regulatory instruments." He stressed that "The precision of our measurements of contaminant concentrations far exceeds the precision of our evaluation of what those concentrations mean to the environment... With more comprehensive understanding of biological effects, we can design the most appropriate regulatory instruments and the best practicable pollution control technology to achieve compliance with those regulatory instruments."

David VanderZwaag emphasized that better technologies will not necessarily lead to better environmental management for at least three major reasons:

1. Lack of an Ecological Perspective

   Courts and legislatures tend to limit compensation for environmental damage to human-oriented concerns, such as harm to property or persons, and refuse to consider pure ecological damage.

2. Lack of Legal Enforcement and Effective Sentencing

   A recent Law Reform Commission of Canada study paper, "Sentencing in Environmental Cases" showed that of 138 convictions, registered under section 33 of our Fisheries Act between 1978 and 1983, only eight resulted in fines over $5,000.

3. Lack of Integrated, Long-Range Water Planning

   An "acceptable" level of pollution or the "environmental capacity" of a lake or stream are not just scientific determinations but should be defined by democratic decision-making processes such as local or regional water planning boards having full public involvement.

   While there are interpretive problems, the standard 96 hour LC50 test quite clearly establishes cause and effect. Toxicologists should give serious consideration to the problems of establishing causation in field studies wherein there are a large number of variables and links in the causation chain.

F. Meth, speaking from the perspective of the regulated, stated that industry wants more evidence that toxicity requirements established in the laboratory must be meaningful in terms of impact on the environment. This dichotomy between the perspective of the lawyer (the simpler tests, the better) and that of the regulator and regulated (the tests must be meaningful regarding impact on the environment) may be difficult to reconcile. F. Meth indicated also that laboratory derived standards of toxicity should not be considered sacred given the natural variability in the environment.

This view was echoed in part by P. Lane. Dr. Lane stressed that toxicologists must improve overall extrapolation capabilities if laboratory results were going to be useful. She described five ecosystem laws which should be kept in mind as extrapolations were attempted.

Law No. 1. Law of Scale Effects: Points in time and space cannot be interchanged indiscriminately.
Corollary No. 1 - If the leaning tower of Pisa was four times bigger, it would fall 24 times faster.
Corollary No. 2 - If the leaning tower of Pisa was eight times bigger, it would not still lean, it would have already fallen.

Law No. 2. Law of Variable Variability: Two average values may be equal but not the same.
Corollary No. 1 - Variability is not directly related to perturbation. Variability can arise as much as a consequence of the structure of the food web as from environmental stress.
Corollary No. 2 - Don't expect too much from averages in ecosystems.

Law No. 3 Law of Indirect Causality: Many causes can have the same effect and many effects can emanate from a single cause.
Corollary No. 1 - Effects are everywhere.
Corollary No. 2 - Change is ubiquitous.

Law No. 4 Law of Feedback and Counterintuition: A variable can affect itself by way of intervening variables in unexpected ways.
Corollary No. 1 - What goes around comes around.
Corollary No. 2 - Anything that can happen will happen (thanks to Murphy).

Law No. 5 Composite Law of Aquatic Toxicology: Physiological truth is not necessarity ecological reality.
Corollary No. 1 - When a toxic chemical is applied to a laboratory bottle, the organism will probably behave in a predictable way.
Corollary No. 2 - When a toxic chemical is applied to an ecosystem, the organism will definitely " do as it pleases".

Lane's ecological laws should give toxicologists reason to pause and reflect on the complications of extrapolating their laboratory data to the field. She argued as did other panelists that additional research is required to 1) improve the realism of laboratory systems and procedures at the ecological as well as organism level and 2) develop better models to understand cause-effect relationship in a biological hierarchy. Similar concerns regarding the lab-field relationshops have also been expressed by John Cairns of the Virginia Polytechnic Institute and others.

Aquatic toxicology has a demonstrated role in protecting marine receiving environments. This is very clear from the past two decades of work on polluted environments. However it seems clear that while regulatory agencies will have to continue to rely on laboratory tests to screen chemicals and to set effluent standards, decisions on the acceptability of the protection may eventually be tempered by baseline data or monitoring results from the ecosystem involved. In some cases, field data may result in greater restrictions on the polluter while in others, the degree of control may be relaxed. However, these decisions must be made in light of the best information and advice available, realizing that the ability to reliably detect chemical effects in the field will substantially improve over the next few years, hence improving the role played by aquatic toxicologists. The strategies for bridging the laboratory-field relationship which might include the selection of appropriate tests, the identification of factors modifying toxicity, the recovery potential of polluted ecosystems, should be discussed in future workshops.

Session 10. ENVIRONMENTAL ASSESSMENT.

EVALUATION ENVIRONNEMENTALE

BESSNER, D., and P. STOKES. Chairpersons

THE USE OF A FUGACITY MODEL TO ASSESS RISK TO AQUATIC ANIMALS OF AGRICULTURAL PESTICIDES USES ON PRINCE EDWARD ISLAND, L. E. Burridge* and K. Haya, Department of Fisheries and Oceans, Biological Station, St. Andrews, N. B., Canada E0G 2X0

Prince Edward Island is Canada's smallest province (5650 km^2). Mixed farming (livestock and produce) and fishing are two major industries in the province. In 1982 approximately 300 pesticide formulations were sold in PEI. This represents at least 115 active ingredients. Over 40 of these formulations were sold in quantities exceeding 1000 Kg or 1000 L.

When faced with this volume of products, deciding where to begin assessing risks to aquatic species is a problem in itself. Certain pesticides raise concerns solely because of their acute toxicity to aquatic biota or their bioaccumulation potential. These properties alone do not describe fully the situation. One must know if an organism is apt to be exposed to the pesticide and at what concentration. It is also important to have an estimate of the environmental fate of the pesticide.

The fugacity model of MacKay (1979) combines quantitative parameters (Henry's constant, adsorption coefficient, octanol- water partition coefficient and application rates) to calculate expected equilibrium concentration (EEC) in a six-compartment model ecosystem. The compartments described in this model are: air, soil, water, suspended solids, aquatic biota and sediment.

The fugacity model has been modified according to Zitko and McLeese (1980). Fugacity, EEC, lethality index, hazard index and bioconcentration factor (BCF) are calculated. The lethality index is determined by dividing the lowest LC50 of a pesticide into its EEC in water. Hazard index is the lethality index times the BCF. Hazard indices are expressed relative to that of malathion (an organophosphate insecticide). Malathion was chosen because of its extensive use and because there is a good data base regarding its properties.

The size of the six compartments are estimated according to available data regarding soil type, freshwater and near-shore water depth and productivity. Some compartment sizes and information regarding concentration of lipid, suspended solids, and organic carbon in the compartments are assigned arbitrarily. This reflects the general lack of information regarding ecosystem characteristics. Compartment sizes were assigned assuming input to a farm, stream, pond system (freshwater). In addition a separate set of parameters were assigned for a 1 Km^2 near-shore, estuarine system (seawater). The compartment sizes are listed in Table 1.

Table 1. SIZE OF COMPARTMENTS IN EQUILIBRIUM DISTRIBUTION MODEL

COMPARTMENT	FRESHWATER (m^3)	SEAWATER (m^3)
AIR	1.0E 9	1.0E 9
WATER	1.0E 5	2.5E 6
SUSP. SOLIDS	1.0E 5	2.5E 6
SEDIMENT	2.5E 3	2.5E 4
AQUAR. BIOTA	1.0E 5	2.5E 6
SOIL	1.9E 5	1.0E 6
SPECIES	Trout	Marine invertebrates

The relative hazard indices of pesticides are listed in

Tables 2 and 3. Only the top ten compounds are listed along with their relative hazard index. The hazard index for malathion is 1.4E+3 in the freshwater system and 4.3E+4 in the seawater system.

Table 2. Pesticides used in PEI with the highest relative hazard indices: Freshwater system.

COMPOUND	RELATIVE HAZARD
CHLORPYRIFOS	7.9E+01
PHORATE	6.7E+00
CHLORDANE	5.4E+00
CYPERMETHRIN	2.4E+00
DINOSEB	2.4E+00
METHIDATHION	2.1E+00
TRIFLURALIN	1.4E+00
MALATHION	1.0E+00
CAPTAN	1.0E+00
DICOFOL	4.1E-01

Table 3. Pesticides in use in PEI with the highest relative hazard indices; Seawater system.

COMPOUND	RELATIVE HAZARD
CHLORLPYRIFOS	5.6E+02
DINOSEB	2.7E+01
MALATHION	1.0E+00
CARBOFURAN	1.3E-01
FENVALERATE	5.3E-02
DIAZINON	3.8E-02
PHOSMET	8.7E-03
METHOXYCHLOR	2.0E-03
CARBARYL	1.3E-03
FERBAM	6.9E-04

Chlopyrifos, an organophosphate insecticide, has the greatest relative hazard index in both freshwater and seawater models. In fact, it is an order of magnitude greater than the next highest compound. Obviously, chlorpyrifos is one compound that warrants closer attention. Fortunately, it is not one of the pesticides sold in large quantities.

Dinoseb, a dinitrophenol herbicide, also ranks highly on both lists. In contrast to chlopyrifos, dinoseb is used extensively in PEI. Like chlorpyrifos, dinoseb has been a target of considerable research. Monitoring of the use of this compound must be continued.

Phorate, another organophosphate, is an example of a compound which ranks very high in terms of relative hazard index, is extensively used, and yet little information is available regarding its action and fate in the aquatic environment. There is insufficient data available to assess its risk to the seawater system.

There is also a pyrethroid pesticide within the top five compounds in each table. This class of compounds also appear to need further study to determine their fate in the aquatic environment. These compounds are highly toxic to fish and aquatic arthropods, in particular.

Table 4 lists the pesticides sold in large quantity in PEI along with their ranking in each model system. The most outstanding feature of this table is the number of pesticides for which a complete set of required data could not be obtained to use the model.

Table 4. Compounds sold in quantities exceeding 1000 Kg in PEI in 1982 and their rankings according to relative hazard index (ranking freshwater, ranking seawater).

aldicarb (36,0)
amitrole (58,0)
atrazine (34,0)
benomul (18,19)
carbofuran (32,4)
chlorfenvinphos(28,17)
chlorothalonil (29,0)
chlorpropham (0,0)
crotoxyphos (0,0)
dalapon (40,0)
diazinon (19,6)
2,4,D (66,0)
difolatan (0,0)
dinoseb (5,2)
diquat (0,0)
disulfoton (25,20)
fenvalerate (30,5)
mancozeb (0,0)
mal./hydr. (61,0)
maneb (0,0)
MCPA (35,0)
metaxyl (60,0)
methamidiphos (63,0)
methidithion (6,0)
metiram (0,0)
metribuzin (53,0)
naptalam (0,0)
oxydemeton methyl (0,0)
paraquat (0,0)
permethrin (27,15)
phorate (2,0)
pirimicarb (57,0)
ronnel (0,0)
thiabendazole (0,0)
thiophanate methyl (0,0)

0 indicates incomplete data set; no assessment

The use of the fugacity model has drawn attention to the lack of information regarding many commonly used pesticides. For some compounds, when sufficient date could be found, certain parameters had to be estimated according to established structure-activity relationships. Henry's constant and octanol-water partition coefficient were frequently determined in this manner.

When used as a tool the fugacity model facilitates the following:

1. handling large groups of compounds as in the PEI situation.

2. comparing one compound with others using the same parameters

3. predicting the environmental fate of compounds

4. organizing research priorities according to potential hazard or lack of available date i.e. identifies gaps in current knowledge.

Models must be used as guides: tools of the profession. This version of the fugacity model does not account for degradation or advective loss in the environment. Therefore, the results may not be fully representative of the real world. The information provided by the model must be assessed with care, keeping the short-comings of the technique in mind.

The results of this exercise have led to the conclusion that further work must be carried out to determine physical constants of pesticides and the relationship of these constants to environmental effects. Of equal importance, further work must be carried out in the lab and in the field to determine the persistence, bioavailability, and long term effects of pesticides such as phorate and the pyrethroids which have almost certainly found their way into the aquatic environment. This fugacity model can also be a useful tool in assessing the risk of so-called "inert" ingredients present in the 300 formulations used in PEI.

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Keywords: Agricultural pesticides, Fugacity, Risk Assessment, Prince Edward Island, Environmental Modelling.

Dans la province de l'Ile-du-Prince-Edouard plus de 300 formulations de pesticides contenant au moins 115 ingrédients actifs sont utilisés à des fins agricoles. Plusieurs de ces composés sont utilisés en quantités qui dépassent 1000 kg/année. La technique dévelopée par Zitko et McLeese (Can. Tech. Rep. Fish. Aquat. Sci. #985, 1980) a été utilisée afin de sélectionner parmi ce grand nombre de composés, lesquels posaient un risque excessif aux animaux aquatiques. Le modèle de fugacité de McKay (Environ - Sci. & Tech. 13, 1218-1223), 1979) fut utilisé pour; prédire les concentrations environnementales attendues. Des données de toxicité sont utilisées pour développer les indices de létalité et les indices de danger sont déterminés relativement aux données sur le fénitrothion, un insecticide forestier bien étudié. Les pesticides pyréthroides semblent être les composés qui posent le plus d'inquiétudes sur l'Ile-du-Prince-Edouard.

Mots clés: pesticides agricoles, évaluation de risque, Ile-du-Prince-Edouard

Paper: THE USE OF A FUGACITY MODEL TO ASSESS RISK TO AQUATIC ANIMALS OF AGRICULTURAL PESTICIDES USED ON PRINCE EDWARD ISLAND

Speaker: L. E. Burridge , Dept. of Fisheries and Oceans, St. Andrews, Canada

C. Blaise, Environment Canada, Montreal: With what organism(s) are the LC50's calculated for the fugacity model?

L. E. Burridge: Mainly rainbow trout for freshwater and one or more organisms for seawater.

ECOTOXICOLOGICAL ASSESSMENT AT THREE LEVELS OF ENVIRONMENTAL PROTECTION, (1) R. Van Coillie, (1) N. Bermingham, (1) C. Garceau, (2) Y. Roy and (3) R. Verdon

Wastes discharged to receiving waters should be assessed keeping in mind three levels of environmental protection. As far as the first level is concerned, local impact is considered as well as initial correction measures to be applied. With this perspective, causes of toxicity (contaminants, pathogens, etc) and lethal effects are identified. At a second levels, regional impact is weighed against the assimilative potential of the receiving water. Here, sublethal toxicities acting upon major food chain representatives (bacteria, algae, zooplankton, fish) must be known. Insidious and/or chronic effects (mutagenicity, carcinogenicity, bioaccumulation, etc) make up a third level of environmental concern which must be dealt with if selective treatment of wastes is to be considered. We have taken advantage of this three level approach to evaluate organic industrial effluents, dumpsite landfill waters and elutriates of heavily contamined sediments. An assessment scheme such as this allows an integration of causes, effects and proposed treatment relationships

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Les rejets dans le milieu aquatique peuvent être évalués selon 3 niveaux de protection environnementale. Au premier niveau, l'impact local est considéré en vue de mesures correctives à la source. Dans cette perspective, les causes de toxicité (contaminants et agents pathogènes) et leur effet létal sont évalués. Au second niveau, l'impact régional est estimé en fonction de la capacité assimilatrice du milieu récepteur; pour cela, on détermine les toxicités sous-létales chez des représentants de la chaîne écologique de ce milieu (bactéries, algues, zooplancton, poissons). Au troisième niveau, les effets insidieux et/ou chroniques (mutagénicité, carcinogénicité, bioaccumulation, etc.) sont envisagés en vue de traitements sélectifs. Cette approche à 3 niveaux a été appliquée pour évaluer des effluents industriels organiques, des eaux de dépotoirs et des élutriats de sédiments très contaminés. Elle permet d'intégrer causes, effets et traitements.

AN INNOVATIVE APPLICATION OF ALGAL BIOTESTS IN ESTIMATING BIOACCUMULATIVE POTENTIAL OF HEAVY METALS IN WASTEWATER EFFLUENT PLUMES, N. Bermingham , R. Vezeau, R. Legault and S. Bisson.

The green alga Chlamydomonas variabilis has been used to estimate the potential accumulation of heavy metals in two wastewater effluent plumes. Coupling in vitro bioanalytical results to in situ algal biomass values, considering expected time of exposure and heavy metals concentration at various effluent dilutions, accumulative potential and spacio-temporal limits of measurable impact have been estimated.

With the initial limit of sensitivity of the biotest, the accumulative potential of four (i.e. Fe, Al, Cr & V) of the sixteen heavy metals studied showed quantifiable results. A subsequent modification to enhance the sensitivity of the biotest successfully increased detection limits to potentially quantify all of the eight metals studied anew (i.e. Fe, Al, Cr, V, Cu, Pb, Zn and Ni).

Addition of such a biotest to a battery of conventional biotools provides a more thorough and realistic estimation of environmental impact.

L'algue verte Chlamydomonas variabilis a été utilisée pour estimer le potentiel d'accumulation de certains métaux se trouvant dans les rejets aqueux de deux effluents industriels. L'information obtenue de cette bioanalyse effectuée in vitro, couplée aux valeurs de biomasses phytoplanctoniques du milieu tout en considérant les temps d'expositions appropriés selon diveres concentrations d'effluents dans le milieu récepteur, ont servi pour estimer l'accumulation potentielle et déterminer les limites spatio-temporelles de l'impact.

Selon la sensibilité des premiers biotests effectués, le potentiel d'accumulation de quatre (i.e. Fe, Al, Cr et V) des seize métaux étudiés était quantifiable. Une modification destinée à accroître la sensibilité du biotest a accru les limites de détection, permettant de quantifier les 8 métaux étudiés à nouveau (i.e. Fe, Al, Cr, V, Cu, Pb, Zn et Ni).

L'addition de ce genre de biotests à une batterie d'outils analytiques permettra un meilleur estimé des impacts environnementaux.

ASSESSMENT OF THE INORGANIC BIOACCUMULATION POTENTIAL OF AQUEDOUS SAMPLES WITH ALGAE,

S. Bisson, N. Bermingham, and C. Blaise , C & P, Environment Canada, Longueuil, QUE. J4K 1A1

The use of a diverse battery of biotests is essential in any integrated ecotoxicological assessment of wastewater samples and chemical substances. As far as chronic agression is concerned, bioaccumulation is certainly a problem which must be appraised rapidly. We have therefore developed a relatively simple procedure to detect inorganic accumulation potential in phytoplankton. In devising the experimental protocol, a specific biomass of the green alga *Chlamydomonas variabilis* was first of all exposed to sublethal concentrations of metals in solution. Algal cells were then irradiated (U.V. rays) to destroy organic content in order to unbind any accumulated inorganic constituents. The toxic expression of the latter, which was next determined by conducting a microtest with the green alga *Selenastrum capricornutum,* was indicated of an accumulation potential for *C. variabilis.* Recent results have shown marked toxicity differences between control algae and those exposed to metals. A good correlation also exists between chemically-quantified metal concentrations in algal cells and corresponding toxicity revealed by the microtest.

Keywords: bioaccumulation, metals, algae, biotests

Dans le cadre de toute évaluation écotoxicologique de rejets industriels et de produits divers, il est primordial de faire appel à des biotests variés. Pour ce qui est de la toxicité chronique, la bioconcentration, entre autres, doit pouvoir être diagnostiquée rapidement. A cet effet, nous avons développé une méthodologie relativement simple pour déterminer un potentiel d'accumulation minéral chez le phytoplancton. Le protocole expérimental élaboré consiste tout d'abord à exposer une biomasse précise de l'algue verte *Chlamydomonas variabilis* à des concentrations sublétales de métaux en solution. Les algues sont ensuite irradiées (rayons ultraviolets) afin de détruire leur composante organique et ainsi "libérer" la composante inorganique. L'expression toxique de ce dernier, vérifié en réalisant un microtest subséquent avec l'algue verte *Selenastrum capricornutum*, témoignera alors d'un potentiel d'accumulation pour l'algue *C. variabilis*. De récents résultats ont déjà permis de mettre en évidence des différences de toxicité marquées entre les algues témoins et celles exposés aux métaux en solution. Par ailleurs, il existe une bonne relation entre la quantité métallique accumulée chez les algues et la toxicité révélée par le microtest.

Paper: ASSESSMENT OF THE INORGANIC BIOACCUMULATIVE POTENTIAL OF AQUEOUS SAMPLES WITH ALGAE

Speaker: C. Blaise, C & P, Environment Canada, Longueuil, Canada

K. Holtze, Ontario Ministry of the Environment: Given that we know pH is a factor regulating bioavailability of metals, does your technique allow you to examine this as a modifying function to metals uptake?

C. Blaise: This is a verification test to find out whether there is inorganic accumulation. The test is for a duration of 24 hrs and during that period the pH is maintained more or less the same to avoid influence due to pH.

USE OF STRUCTURE-FUNCTION RELATIONSHIPS FOR MONITORING CELLULAR STRESS AND ACCLIMATORY RESPONSES WITH SELENASTRUM CAPRICORNUTUM,

(1) Patsy-Ann Thompson, (1) Pierre Couture, (2) Claude Thellen and (1) Jean-Christian Auclair

The toxicity of cadmium and of an industrial effluent was studied using both structural and functional properties of Selenastrum capricornutum populations. Results showed that photosynthetic efficiency is a better indicator of the sub-acute effects of cadmium than is biomass or average growth rate (u_{av}). The industrial effluent had greater short-term effects on both photosynthetic efficiency (P/B ratio) and adenylate energy charge (EC_A) than did cadmium. Furthermore with both toxicants high P/B ratios and EC_A are observed at the end of the experiment when cell densities are still low, suggesting that these functional parameters can be useful in the detection of acclimatory responses to toxicants. Moreover, EC_A appears to remain low only under conditions of acute stress.

Keywords: toxicity; cadmium; industrial effluent; structure-function relationships; Selenastrum capricornutum

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La toxicité du cadmium et d'un effluent industiel à été étudié en utilisant les propriétés structurales et fonctionnelles chez des populations de Selenastrum capricornutum. Les résultats démontrent que l'efficacité photosynthétique est un meilleur indicateur des effets sub-aigu du cadmium que la biomasse ou le taux de croissance moyen (u^{av}). L'effluent industriel avait de plus grands effets à court terme sour l'efficacité de la photosynthèse (ratio P/B) et une charge energétique adenylée (EC_A) que le cadmium. De plus, des rapports P/B et EC_A élevés chez les deux produits toxiques ont été observé à la fin de l'expérience quand les densités cellulaires sont encore peu élevés. Ceci suggère que ces paramètres fonctionnels peuvent être bénéfiques dans la détection d'une accumulation de produits toxiques. De plus, EC_A semble être faible seulement sous des conditions de stress aigu.

BIOCHEMICAL INDICATORS FOR STUDYING SUBLETHAL EFFECTS OF POLLUTANTS, J. Pellerin-Massicotte and E. Pelletier, Institut national de la recherche scientifique, 310 des Ursulines, Rimouski, Quebec, Canada G5L 3A1

The aims of our research are to develop biochemical indicators having the capacity to detect sublethal effects of pollutants in marine organisms. Such indicators could be useful in the choice of favorable sites for projects in aquaculture, or to assess the quality of a marine environment intended to commercial fishing or recreational purposes. Bivalve molluscs are excellent indicators of environmental pollution by their ability to accumulate pollutants. Toxic effects could then be observed and evaluated by biological measurements. However, small concentrations of pollutants, persistence of a pollutant in the environment or the recovery of a population from a stress bring about new difficulties in the evaluation of possible sublethal effects: they are not easily recognized and measured.

Since the responses to a stress affect both glycolysis and lipid biosynthesis in the blue mussel *Mytilus edulis* L. , we intend to study the variations of the mantle malate dehydrogenase activity to sublethal concentrations of methylmercury hydroxide. Malate dehydrogenase is a non-regulatory enzyme, involved in the citric acid cycle, the metablic pathway leading to the oxydative degradation of glucose, and is also involved in the pathway of lipid biosynthesis.

Blue mussels were sampled on a rocky substrate at Pointe Mitis, Que. They were kept for 29 days in 20 liters sea water tanks supplemented with *Phaeodactylum tricornutum* , mineral salts and two sublethal concentrations of methylmercury hydroxide. Each group was sampled at days 0, 1, 3, 7, 15, 22 and 29; animals, mantles and the posterior adductor muscles were weighed and the sex was determined by microscopic examination of mantle smears. Tissues were then homogenized in Tris-sucrose buffer and centrifuged to obtain crude cytosolic and mitochondrial fractions and kept at -70°C. Analysis of malate dehydrogenase activity was performed on cytosolic fractions using 5 ug proteins in each assay.

Exposure of blue mussels to 0.3 ug methylmercury/Liter led to the bioaccumulation of the pollutant to a level of 0.5 ug mercury/g wet weight of the whole soft tissues. Bioaccumulation reached a plateau at day 7 indicating the presence of a mechanism of detoxification. The presence of 3.0 ug/L methylmercury led to the bioaccumulation of mercury throughout the experiment. Both concentrations of the pollutants were really sublethal because either did not affect the survival of the animals, the body weights and the mantles and posterior adductor muscles wet weights. Protein contents were also unchanged in the tissues of both sexes.

The variations of the mantle malate dehydrogenase activity were then studied and evaluated by estimations of the Vmax and the Km.

Both treatments led to a significant increase of MDH maximal specific activity after 1 day of treatment in female mussels, before reaching control levels at day 3 for the lower concentration and a few days later for the highest concentration. In males, the effects were opposite of those observed in the female. MDH maximal activity was significantly decreased after 3 days of both treatments before reaching control levels after 5 days. We further investigated the enzyme characteristics at day 29. As seen in the figure, the Km of MDH in control mussels was of 0.2 mM oxaloacetate. The presence of 0.3 ug/L methylmercury led to mixed effects. One male and one female mussels had a Km similar of that of control with an increased maximal activity while the two others had a Km and a Vmax similar to those observed with the highest concentration of the pollutant. The effects of 3.0 ug/L methylmercury were more consistent. This concentration led to a displacement of the Km to the right for both males and females, about four times the Km observed in controls and without affecting the animal enzyme activity.

We can therefore postulate that the most accurate and differentiating biochemical response to pollutants is the evaluation of the Km. It provides us informations about the presence of an inhibitor and the level of the competitive inhibition by its displacement to the right. The mixed effects observed with the lower concentration of methylmercury could be explained by the normal biologic variation among individuals. These results strenghthen our conviction to evaluate sublethal effects in individuals among a population. In our future work we will extend the number of animals studied and we will evaluate the variations of three more enzymes, pyruvate kinase, succinate dehydrogenase and phosphoenolpyruvate carboxykinase.

In the establishment of a biochemical indicator for detecting sublethal effects of pollutants or other factors, we should consider the important variability due to the season of the sampling and to the sex of the individuals. Our system is able to detect sublethal effects at the level of enzyme activity and can give us precise indications about the modification of enzyme characteristics. The availability of such biochemical indicators would be precious to predict if an organism is adversely affected by an unknown contaminant, an information valuable for projects in aquaculture. It would be also useful in the assessment of the quality of a marine environment and in the monitoring of the persistent of pollutants.

Keywords: bioindicators, mussels, pollution, enzymes, marine organisms.

Les bivalves et les algues macroscopiques sont des indicateurs efficaces et fiables pour la détection de la pollution des métaux tracés dans les environnements estuariens et marins. Par contre, la persistance des polluants dans l'environnement et/ou un niveau faible de contamination peut induire des effets toxiques qui sont indétectables par les techniques actuelles d'observation biologiques. Nous discuterons ici du développement d'indicateurs biochimiques ayant la capacité d'évaluer les effets toxiques des polluants chez la moule M. edulus.

Des enzymes clés provenant du cycle d'acide citrique et du métabolisme d'hydrates de carbones tels que Pyruvate kinase (Pk) malete déshydrogénase (MDH) succinate déshydrogénase (SDH) ainsi que phosphoenolpyruvate carboxinase (PEPCK) à partir des mateaux individuels et des muscles adducteurs postérieurs groupés. Les mesurations étaient assez sensibles pour démontrer que les activités enzymatiques du manteau sont dépendants du sexe avec des variations saisonnières marquées et que'elles sont affectées par des longues expositions à l'eau salées. L'activité enzymatique des muscles adducteurs ne fut pas affecté pendant les 6 mois qu'à durée l'expérience. Les résultats préliminaires d'activités enzymatiques chez les moules cueillies en milieu

pollué seront aussi presentés. Nous pouvons déjà postuler que les agents biochimiques pourraient agir comme indicateurs d'effets subletaux de polluants.

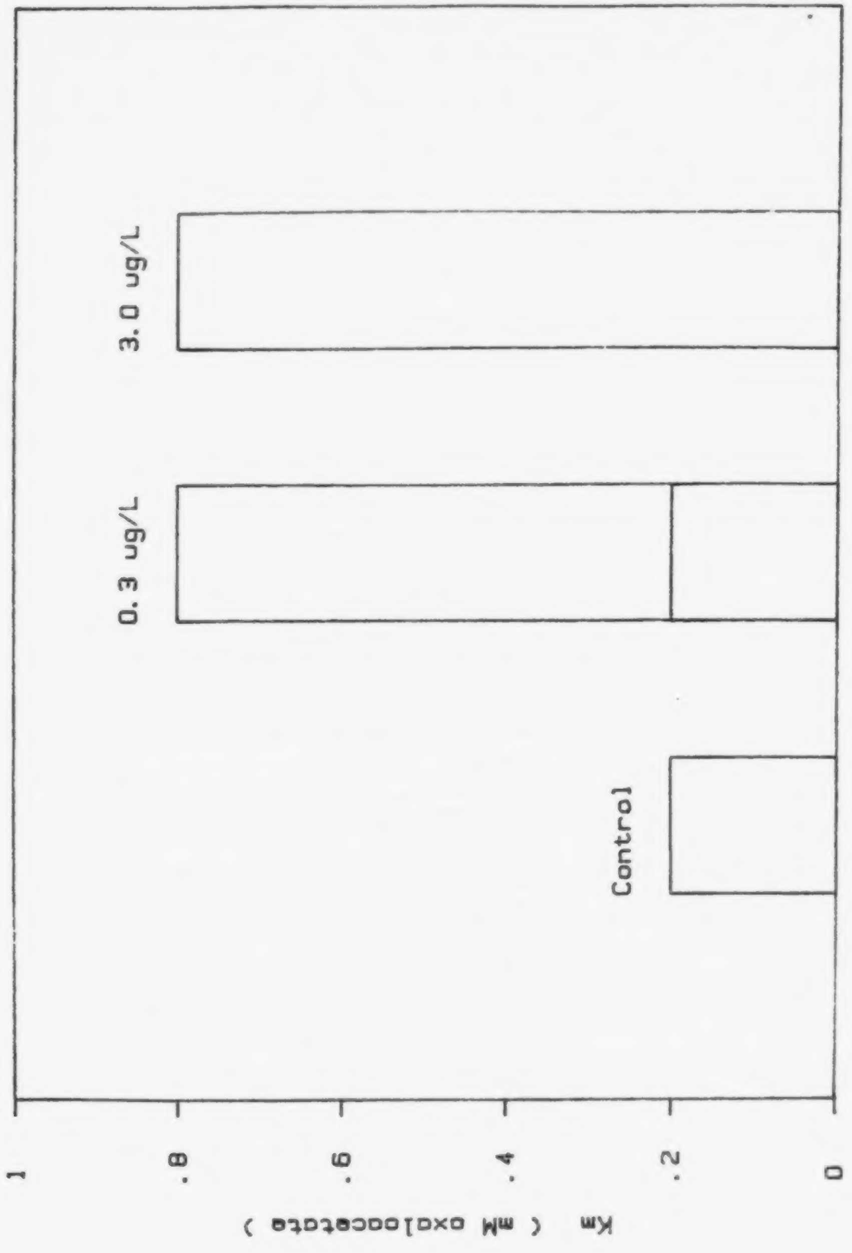

FIGURE 1 Effect of methylmercury on the Km of Malate dehydrogenase

Paper: BIOCHEMICAL INDICATORS FOR STUDYING SUBLETHAL EFFECTS OF POLLUTANTS

Speaker: J. Pellerin-Massicotte INRS, Rimouski, Canada

D. Besner, N.B. Municipal Affairs and Environment: At what concentration of methylmercury do we see lethal effects to the mussels?

J. Pellerin-Massicotte: For example, at 30 μg/l, there is some mortality at 12 days.

Session 11. SUMMARY SESSION

McCORMICK, J. HOWARD. Chairperson

CLOSING SUMMARY SESSION 13TH ANNUAL AQUATIC TOXICITY WORKSHOP, MCCORMICK, J. HOWARD, Chairman

After publication of a proceeding reading the abstracts provides useful information. There were some valuable overviews and thoughts presented during the summary session which are to be found in the abstracts.

Observations of M. Waldichuck, S. MacKnight and others include the need to be constantly on guard to keep the ultimate goal of research in mind, which is to provide needed information so that the environment can be adequately conserved. As applied scientists, we are obligated to perform not only good science but to also provide answers to questions. Answering some questions with greater precision may not be necessary, and may be achieved by failing to provide information for more critical questions. G. Westlake illustrated this when he suggested that many dischargers fail to achieve 96 hr. TL50 limits, let alone sublethal long-term exposure concentrations. If the organisms are already dead there is little need to be concerned about potential long-term, sublethal effects.

A historical overview and future prospectus was presented by P. Wells who reviewed topical trends as they have evolved through the years. In the early years there was much involvement in methods for laboratory bioassays. Questions such as size of exposure tanks, loading rates, flow through-vs static exposures, flow rates, exchange frequencies and numbers of organisms per exposure unit - all these were then unknown. Some of these questions remain unresolved, but at this meeting, a new trend seems well advanced. A movement is now underway to foresake our secure laboratories in favor of the place of application-into the area of potential impact of actual discharges. We are now asking questions about how well our laboratory derived predictions match true effects. We are asking why there are, in some cases poor relationships, and in others good relationships (J. M. Holtze and N. J. Hutchinson and others). This is an exciting new phase of our science. We are bound to be frustrated and disappointed at times, but as a result of dealing with these new questions our science is going to advance and be in greater demand.

From this new viewpoint, we can gain a lot more from already completed environmental impact statements and subsequent environmental monitoring. This is an area that has not been adequately tapped and our failure to tap it is disgraceful since this information has already been paid for.

Another trend revealed a less parochial view of our area of responsiblity. Canada and North America were discussed in asssociation with European concerns. L. Lockhart presented a sweeping global view of environmental concerns including comments about polar regions as toxicant sinks and a final slide stating that the environment is "not for sale."

Nevertheless, we must not be overly zealous. "We, the people" are the polluters and it is our demand for products at affordable prices that spawns pollution. The cost of doing without some products or the expense of having them must be weighed in terms of how much we gain in a short-term lifestyle compared to what it costs the environment (panel discussion chaired by D. Eidt).

The advancing state of the art, was discussed by K. E. Holtze and J. M. Gunn in two separate presentations. They talked about applying toxicity test data for a particular organism to that place and time in the environment when the tested life stage is extant. They pointed out that intermittent exposures are just as likely to occur as constant exposures. In addition, it was stated that short-term exposures can result in delayed mortalities (N. J. Hutchinson et al.) or in recovery if exposures are of short enough duration (J. H. McCormick et al.). Sediments must be considered as a habitat for aquatic organisms and as a source or sink of toxic substances in the aquatic ecosystem (J. S. Wang et al., K. K. Kwan et al., and P. E. Ross et al.). Since stress in the natural environment is seldom induced by a single factor, others are studying combinations of factors such as temperature-arsenic, (S. M. McGreachy and D. G. Dixon); pH and aluminum, (A. Haot and P. Thompson). Finally, generalized schemes to apply what is known were presented as one means of consistently using the data to arive at a safe-unsafe decision (R. Van Coillie and C. Blaise).

Another aspect of this decision making process was raised in response to D. Vanderzwaag's comments during the panel discussion: Aquatic Toxicology and the Management of Marine Environmental Quality - Its Role, Opportunities and Constraints. The comment made reference to the common practice of determining "effect" "no effect" concentration in bioassay using 95% or even 99% Confidence Limits. Such high limits are used to limit "accusing" and innocent concentration of a substance of being "guilty". The commenter's suggestion was that the potential persistence of the substance once discharged should be carefully considered when choosing the decision point. Sometimes we fail to recognize the fact that by choosing a level of probability to limit the chance of falsely accusing the innocent we unavoidably and proportionately increase the chance that the guilty might escape judgment. Not only should the toxicity of the substance be considered but also its persistence. Persistence is critical because once we have made an error we must endure the consequences which may exceed our endurance leaving us helpless. For persistent toxicants something less than a 95% C. L. may be justifiable, or might be the only reasonable approach. Are we so afraid of calling the innocent subtance guilty that we may allow the worse offender to escape our judgement?

These complex, more realistic concepts of aquatic toxicology are now being routinely investigated and our ability to predict will be better because of it. I believe we are maturing into a more useful profession.

ADDRESSES OF DIGNITARIES

His Worship George Rideout,
Mayor of Moncton,
Moncton, N.B.

Hon. Robert C. Jackson
Minister of Municipal
Affairs and Environment,
Province of New Brunswick

Mot de bienvenue aux participants du 13e atelier (annuel) sur la toxicité aquatique the 13th (annual) Aquatic Toxicity Workshop

par

Dr. Louis-Philippe Blanchard, Recteur,
Université de Moncton, Moncton,NB

Monsieur le Président du 13e atelier sur la toxicité aquatique,
Your worship M. le Maire de la Ville de Moncton,
L'Honorable ministre des Affaires municipales et de
l'Environnement du Nouveau-Brunswick,
Mesdames et Messieurs les participants,

L'Université de Moncton, a young and dynamic institution of higher learning in our fair city, is proud today to act as one of the principal sponsors of this all important workshop.

The subject of your workshop: AQUATIC TOXICITY, brings some 100 of you together under a single roof to share with each other and with the public in general through the media the fruits of your research.

L'Université de Moncton qui est la plus grande université canadienne hors Québec entièrement de langue française et troisième en importance aux provinces Maritimes, avec des quelques 5000 étudiants et étudiantes, est particulièrement heureuse de pouvoir jouer un rôle actif dans ce 13e atelier annuel. And this, ladies and gentlemen, all the more so since l'Université de Moncton recently took steps to set up a Centre for Research on the Environment/le Centre de recherche sur l'environnement which will group some 15 scientists, engineers and students in a common goal and which will have as a starting annual budget upwards of 200 000$.

Many of you come from areas nearby while many more are from regions located many hundreds (if not thousands) of kilometres away. But like our new and modest group at l'Université de Moncton you all share a common concern namely: the quality of the waters that surrounds us.

The marine life that inhibits these waters and we who feed off it can certainly be affected by the presence of foreign substances in our waters.

Ai-je besoin de vous rappeler les tristes incidents du passé alors que de nombreux japonais ont été intoxiqués (beaucoup même en sont morts); ou encore, beaucoup plus près de nous, l'intoxication par le mercure de plusieurs amérindiens qui s'alimentaient dans les rivières du nord de la province de l'Ontario.

Looking over your technical program, I note with interest that the topics you will treat cover a wide range of subjects. To name but a few we find:

a) The influence of hydrogen and aluminum ions on the eggs and fry of land-locked salmon;

b) A rapid analytical procedure for cyanide determination in aqueous samples;

c) La contamination par le mercure et les BPC de sept bassins versants du fleuve Saint-Laurent;

and there are many many more equally diversified and interesting subjects. I wonder what will be said in coming years when studies on the Rhine waters are reported on.

Ladies and gentlemen, you are carrying out very important work which has been made possible by the training you received in our many university institutions where research of quality if carried out 1) no doubt to discover new knowledge, and 2) to train young and promising research scientists and engineers who, like many of you, have the important responsability of maintaining (or might I add of even restoring) an environment where we can live in peace and especially in good health.

This will not be possible to the same extent in the future if our universities do not obtain the necessary means to continue and expand the crucial role they are required to play in our society. Nor will it be possible if university research (and I include that being carried out in the regions located further away from the central provinces of Canada) is not better funded than it is at present or will be in the future with the policies presently being persued. 2.5% of GNP is a target that we are a long long way from reaching!

Je vous demande, je voudrais même vous supplier, I ask you in the most forceful manner to bring this message home to all those who are responsible for the decisions made in these matters. Remind those concerned that there are even many many votes to be obtained (and even profits to be reaped) from funds invested in university training and research!

May the next three days be fruitful ones for each and every one of you but may the months and years to come be better still.

Bonne journée à tous.

Address by

The Honourable Robert C. Jackson

Minister of Municipal Affairs and Environment,
Government of New Brunswick,
Fredericton, New Brunswick

Thank you, Mr. Chairman,

I am very pleased to join you today for the 13th Annual Canadian Aquatic Toxicity Workshop.

I also bring sincere greetings to all of you who are visiting our province. On behalf of Premier Richard Hatfield and the people of New Brunswick. I trust your stay in the Moncton area will prove to be both productive and enjoyable.

As Minister of Municipal Affairs and Environment, I must say I appreciate the fact that you have chosen to hold your workshop in our province this year.

The Department relies a great deal on aquatic toxicity data for many of its environmental management programs.

It's obvious that without the hard data and relevant focus that such research provides,...our environmental planners would have little or no information to serve as a base for management decisions.

This is true whether we are gathering baseline data to assess anticipated impacts of development on our fresh water systems,...or whether we are determining cleanup strategies for contamination problems from established sources.

We are, of course, working continually to expand our own technical capabilities in this area. For example, the department has recently expanded our inhouse analytical capability ...to provide a greater range of detection and measurement functions.

Over the past year, we have upgraded and modernized our organics laboratory .....at a cost of more than one hundred thousand dollars.

Nevertheless, we still depend on the federal government and other agencies ...for the bulk of our research and analytical requirements for aquatic toxicity.

I would like to briefly summarize the many areas where aquatic toxicity data plays a key role in New Brunswick's environmental management strategy.

First of all, it is obviously crucial in water quality management. In situations where a water resource is being put to one or more sustained uses, ...aquatic toxicity data is applied to define the levels of various contaminants which aquatic life in these waters can tolerate.

This information is particularly important in New Brunswick, as you know, this province enjoys a worldwide reputaion for its recreational angling opportunities.

Reliable aquatic toxicity data helps us protect our waterways so that the sport angler can pursue his passion ... on the same river used by industry in its quest to supply markets at home and abroad.

To give another example, our cooperative water quality programs with the state of Maine, Quebec, and the Government of Canada ... involving the international portions of the Saint John and Saint Croix Rivers ......are based on obtaining and analysing scientific data for these waterways.

Toxicity information is also used to design manufacturing plants and waste treatment facilities in New Brunswick. Industry planners use this data to meet the dual goals of efficient manufacturing capacity, and protection of the aquatic environment.

Such information is equally important in supporting the department's role as regulatory agency for pesticide use in New Brunswick.

Planners analyse the data along with other factors ...such as persistence and drift ...to determine conditions for permits to apply pesticides. This information is also used to develop guidelines for pesticide container handling and disposal.

Toxicity data plays a vital role in dealing with environmental emergencies as well. As you are well aware, cleanup measures following a spill often depend on the toxicity of the contaminant involved.

Given New Brunswick's geographical location ...downwind from the major industrial centres of North America ...we need reliable data to assess the effects of long range transport of air pollution on aquatic organisms throughout the province.

It would not be an exaggeration to say ...that our progress in negotiations with other canadian provinces and american states ...on strategies to reduce the long range transport of air pollution ....hinges on reliable aquatic toxicity information.

In conclusion, ladies and gentlemen, please rest assured ...that the data you have come to Moncton to present will have a significant impact on the success of our environmental protection programs in the years ahead.

Your contribution in this vital area is greatly appreciated ...by our technical staff, provincial decision-makers and residents in all areas of New Brunswick.

Please accept my best wishes for a successful and productive workshop, and I can assure you that we will continue our active support of the aquatic toxicity workshop program in the future. Thank you.

Address of

Mr. Jim Vollmershausen

Regional Director General
Atlantic Region
Environment Canada

Mr. Chairman, Ladies and Gentlemen,

I was really quite pleased when I learned that I would have an opportunity to say a few words at this workshop on aquatic toxicity. As many of you know, Environment Canada is a sponsor of these annual workshops in Canada. We believe your work in this field to be vitally important, and that the products of these workshops, in the form of shared information, revelation of research results, new insights into old problems, and the expansions of our networks represent a net gain.

Having recently returned to Atlantic Canada from Banff National Park where I served as park superintendent for several years and having also been responsible for Gros Morne and Cape Breton highlands national parks, as well as a stint looking after the Trent Severn Waterway, I am not a stranger to the real values of the range of waterbodies and wetlands that exist in Canada. I do see the need for the effective control of water pollution, and the protection of our aquatic ecosystem from human disturbance. The practicing aquatic toxicologist's role in all of this is quite essential. I am not a practicing aquatic toxicologist. I am, however, a conservationist and environmentalist who has had an opportunity for over 17 years now to practice my beliefs as a manager within the federal government.

This past september, I assumed my new responsibilities as Director General of the Atlantic Region of Conservation and Protection, a new service within Environment Canada. The missions of conservation and protection however, is not new: it is to conserve and protect Canada's renewable resources of water, land and wildlife and to influence human activities in a way that will achieve and maintain a state of the environment necessary for the sustained use of natural resources and the natural environment (air, water, soil). Conservation and Protection, or C&P Atlantic as we have come to call it, represents a "new look" to the department in the region and is the result of a consolidation exercise initiated last spring and now essentially complete. Its three major "arms" or components, the Environmental Protection Service, the Inland Waters and Lands Directorate and the Canadian Wildlife Service are now housed "under one roof".

Over the next number of years, Conservation and Protection and Environment Canada will be active in a number of environmental issue areas and I would like to outline for you what we see as some of our priorities.

Toxic substances are of course a major concern. As most of you are probably aware, on Friday, November 7th, our Minister, the Honourable Tom MacMillan, signed an agreement with the Government of Nova Scotia to clean up one of the most toxic waste sites in all of Canada, the Sydney tar ponds.

These ponds, formed as a result of decades of deposition of wastes from the SYSCO coke ovens, are contaminated with significant quantities of polynuclear aromatic hydrocarbons.

known carcinogens. The PAHs contribute significantly to the contamination of the aquatic environment in the Sydney area. Indeed in 1982, after consultation with Environment Canada and Health and Welfare Canada, the Department of Fisheries and Oceans closed the loster fishing in the southern arm of Sydney Harbour after discovering a severe contamination problem there.

The clean up of the tar ponds will take ten years and cost approximately $50 million. It is expected to generate 600 jobs in the Sydney area and a further 850 indirectly within Nova Scotia over the ten year period. Perhaps more important, from an aquatic toxicity viewpoint, a reduction of 94% of th PAH discharges to Sydney Harbor will be achieved on completion of the project, and in time both the lobster fishery and the harbour itsel, returned to a state of good environmental health.

In addition to the Sydney tar ponds, which has received national attention, considerable information is reaching the public about toxic substances and their harmful effects to ecosystems and human health. I am sure that you are all aware of the most recent examples:

- Huge amounts of toxic chemicals entering the Rhine River in Europe, as the result of a fire in a chemical plant and warehouse in Switzerland. All of Europe is in an uproar over this accident, particularly the governments and citizens of the four countries most directly affected. The full impact of this accident is not yet known. It will be incalculable.
- A much smaller warehouse fire in Canning, Nova Scotia, resulted in the introduction of large amounts of toxic chemicals into the local water courses.
- The "St. Clair River blob" in Ontario has been the subject of intense media coverage since last year.
- The "Kenora PCB spill" highlighted the dangers of transporting toxic substances.
- Rio Algom mine wastes reaching the Tusket River in S. W. Nova Scotia has received wide coverage.

The public has been reacting to information about these and other accidents and disasters over the years. As our Minister, the Hon. Tom MacMillan, has pointed out in recent speeches: every recent study of anadians' attitudes shows that only one major attitude has shifted fundamentally since World War II - The public's attitude towards the environment. These studies show that 85% of canadians express concern about the environment, and that 83% would be willing to make reasonable economic sacrifices to protect it. Good news for us.

High priority will be placed on the field testing of agricultural and forestry pesticides, both of which are used extensively in the Atlantic egion. We intend to encourage the completion of longer term research projects on pesticides. Our objectives in supporting both of these will be to monitor the fate of pesticides in the environment, and to modify consumption patterns away from high risk chemicals.

Acid rain continues to be one of our major concerns. We are finalizing acid rain control agreements with each of the provinces. When finalized, we intend to play an active role in monitoring progress of control programs and assessing the extent of acid rain impacts on our receiving wastes.

Because groundwater is so vital to our region, we intend to be active in this area as well. One important aspect of this issue is the problem of leaking underground storage tanks. It is our intention to implement, with the cooperation of provinces and industry, a code of good practice for the design, installation, operation and abandonment of storage tanks.

On the issue of marine environmental quality, we intend to lead the development of a national strategy in this area. We are giving a high priority to the development of memoranda of understanding with Nova Scotia and Newfoundland with respect to offshore accords. Th objective of these MOUs will be to ensure that the exploration and development of offshore hydrocarbon projects will proceed in a safe manner.

Enforcement of existing legislation will continue. As most here know, there has not been any new federal environmental protection legislation for several years. However, many of you will also know that the recent throne speech to open the fall sitting of parliament heralded the introduction of a new piece of legislation, the Environmental Protection Act.

I would like to take a few minutes to tell you what matters will be addressed by that legislation.

It will build upon the Environmental Contaminants Act and consolidate some other pieces of legistation already administered by Environment Canada. It will consolidate part of the Canada Water Act, parts of the Clean Air Act, part of the Department of the Environment Act, and certain amendments to other acts, such as the Access to Information Act.

The new act will provide for the regulation of toxic chemicals to allow for interventions at all phases of the life cycle of these toxic chemicals. The act will authorize the establishment of environmental quality objectives for federal lands, waters, works and undertakings, and will provide for heavy fines for non compliance.

It is recognized, of course, that in the field of toxic chemicals management and control, several pieces of federal legislation exist. These will not be consolidated through the new Environmental Protection Act. Federal legislation, such as the Pest Control Products Act, Transportation of Dangerous Goods Act. Motor Vehicle Safety Act, and Fisheries Act (Sec. 33) will continue to exist and to be enforced. Gaps in the current fabric of federal legislation will be filled and a clear, predictable and fair compliance policy will be ennunciated. Most importantly, as the Federal Minister of Environment has recently stated, "... the onus for ensuring the safety of chemicals will be shifted away from society to... the companies that produce them."

Full consultation with provinces and the public will occur during the next few months as the new act is being developed.

I would like to briefly talk about communication to the public.

Earlier on, I referred to a spate of recent articles in the popular media that proved that considerable information is reaching the public about toxic substances and the damage they can cause. I indicated that the public has shown that they are concerned about the environment. They are now asking valid questions and must receive valid answers or their faith in scientists will be undermined. You as aquatic toxicologists are involved; you have a responsibility. I must refer you to a major criticism of environmental scientists in Canada as put forward by the public and others who have examined this area. They say that while scientists have increased their ability to measure substances in the environment, their ability to interpret the meaning of these measurements has not kept pace. This poses a direct challenge to you as toxicologists. It is up to you to find ways to narrow this gap between our ability to measure and our ability to interpret. And you must then communicate this information to the concerned clients in appropriate ways.

Our own epartment's policy for informing the public is that it should be done and done frequently, through state of environment reports, specific publications, talks to groups and talks with the media (Deputy Minister, Eco-news, October 1986).

Hence, I would encourage you to periodically write for or speak to the public on issues in which you are expert and that you know are important to the welfare of Canadians. The complexity of the environmental problems that you are addressing demands this role, because eventually the public and the policy makers will decide (as they do now) what the future major issues in aquatic toxicology will be and which will receive long-term funding. Such decisions require understanding an knowledge of the problems. You are the experts. You should be expressing yourselves about your work in the public forum to ensure and adequate level of understanding of what we know and what we do not yet know about key water pollution problems. You should address the question of uncertainty of the existing knowledge if that is appropriate (e.g. contaminant-sediment fluxes, and subsequent biotic contamination, impacts of oil in salt marshes, detection of chemically-induced effects in the offshore). Above all, you need to be communicating about your work. The public is interested, judging from the responses to new popular science publications, and to programs such as the nature of thing and others. An informed public will most likely influence the decision makers to make the correct decisions!

Concluding remarks

Your work is important. It is being driven by established and honourable environmental and conservation ethics, and it is receiving public attention as it should. It requires focusing on the "big issues", regionally are nationally and it requires continual communication to the public and the policy and decision makers.

At this meeting, many of the topics you are discussing are ones of direct concern to Environment Canada and other agencies and departments.

On behalf of Environment Canada. I wish you the very best in your endeavours in this vital field of aquatic toxicology.

Thank you very much for the opportunity to talk to you.

CANADIAN WATER QUALITY GUIDELINES

CANADIAN WATER QUALITY GUIDELINES, Margaret C. Taylor, Water Quality Branch, Environment Canada.

The Canadian Council of Resource and Environment Ministers, in 1984, requested production of the Canadian Water Quality Guidelines. A Task Force of representatives from NWT, seven provinces and Environment Canada was formed to oversee this production.

The main purposes of the guidelines are:

a) To promote a uniform Canadian approach to establishing water quality objectives;

b) to make guidelines available that are relevant to Canadian environmental conditions;

c) to promote federal-provincial co-operation in the effective management of water quality.

The Guidelines were presented to the CCREM on October 2, 1986 and the Ministers recommended that they be accepted and published.

Eight authors and approximately 160 reviewers from provincial and federal departments were involved in the production of the guidelines. The federal departments included Environment, Agricultural, Health and Welfare, Fisheries and Oceans, Regional and Industrial Development, and equivalent Ministries in the Provinces and Territories. The reviewers comprised both research scientists and resource managers.

The Guidelines contain recommendations on concentrations of chemical, physical, radiological and biological parameters to protect the uses of a water body. The uses of water are aquatic life, agriculture (irrigation and livestock watering), recreation, raw potable water supply and industrial water supply. Guidelines have been developed for approximately 50 parameters. Included in the guideline document is a chapter dealing with sources, uses, concentrations in the Canadian aquatic environment and environmental fate for about 120 water quality parameters. The Guidelines provide a scientifically based starting point for the development of site-specific water quality objectives.

Only those parameters of concern to a particular water use are discussed in the appropriate chapter. For example, guidelines for dissolved oxygen can be found in the chapter on freshwater aquatic life but not in the chapter on raw potable water supplies. The same toxic chemicals may be discused in most of the water-use chapters if there is sufficient information to recommend water quality guidelines.

The CCREM recommends that the guidelines should not be used as absolute values for water quality as Canada has many types of water across its territory. Each water type has particular characteristics which can modify the effects of chemicals on water quality in different ways. Nationwide water quality objectives can never be developed to meet the individual water use needs of each of Canada's waterways because of this natural variability. Many factors will modify the effect of chemicals on water quality. Exampes of typical modifying conditions include: the local hydrological conditions, the pH and hardness of the water, the dynamics of the resident biotic community: exposure to the toxic chemical; the presence of mixtures of pollutants, etc. Many of the guidelines contain some information on modifications that may be necessary in order to take into account the differing Canadian water quality conditions. However the range of conditions that occurs across Canada is so wide that it is impossible to consider them all in the individual guideline dicussions. Hence, additional information, in the form of site-specific physical-chemical and biological surveys, are required before effective water quality objectives can be formulated.

A second document, a report to the CCREM on the research needs which arose out of writing the guidelines will be presented to CCREM early in 1987 and the recommendations for research will reach the research community. Some chemicals were not covered in the guidelines due to a lack of time, others because there was insufficient information to prepare guidelines. Future activities will be directed towards the refinement of existing guifelines and the development of new ones.

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